[COMMITTEE PRINT]

SEVENTH BIENNIAL CONFERENCE ON NATIONAL MATERIALS POLICY

REPORT

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LETTER OF SUBMITTAL

CONGRESSIONAL RESEARCH SERVICE,
THE LIBRARY OF CONGRESS,
Washington, D.C., December 9, 1982.

Hon. DON FUQUA,
Chairman, Committee on Science and Technology,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am pleased to submit to you these proceedings of the Seventh Biennial Conference on National Materials Policy held in Harpers Ferry, West Virginia, July 19 to 22, 1982. The theme of the conference sponsored by the Federation of Materials Societies was strategies for coping with critical issues related to engineering materials and minerals. To address this timely theme, the conference drew together a balanced group of informed conferees from industry, academia, and Government. The conferees examined what of significance has been accomplished thus far to resolve our materials and minerals problems, and what still remains to be done in dealing with these critical issues.

Pursuant to your request the Congressional Research Service has edited and prepared these proceedings for the committee's publication. The preparation of these proceedings was under the general direction of Dr. James E. Mielke, Specialist in Marine and Earth Sciences, who was assisted by Lennard G. Kruger, Analyst in Science and Technology.

Sincerely,

GILBERT GUDE, *Director.*

Enclosure.

PREFACE

The Seventh Conference on National Materials Policy took on new significance when on April 5, 1982, the Reagan Administration became the first administration in thirty years to issue a key statement on the importance of materials to the economy and to the national security. Much of the discussion at the conference centered around the initiatives taken and issues raised by the President's National Materials and Minerals Program Plan and Report to the Congress. The President's report was required under the provisions of the National Materials and Minerals Policy Research and Development Act of 1980 (P.L. 96–479) which was enacted on October 21, 1980.

Previous conferences had stressed the need for a national materials policy and had worked to build a consensus on the essential elements that such a policy should comprise. This conference was the first to consider as a part of its deliberations, the response to legislation passed by the Congress on national materials policy. Consequently, the conference offered the opportunity for more than 100 persons with special expertise in materials management, education, and research to assess the accomplishments of the legislation thus far, and to provide recommendations on what remains to be done.

The conference addressed five specific issue areas: research and development; manpower, education and training; materials availability; institutional and industrial factors; and materials as a technological force in productivity. A major portion of the conference was devoted to task force deliberations of the conferees in these five major areas of interest.

EXECUTIVE SUMMARY

A number of important themes emerged during the Seventh Biennial Conference on National Materials Policy held on July 19–22, 1982 at Harpers Ferry, West Virginia. Foremost was the importance of a secure supply of materials and minerals at reasonably stable prices.

While it was generally acknowledged that actions such as stockpiling, materials substitution, expanding domestic minerals production, and enhanced materials R&D can help reduce the nation's materials vulnerability, debate centered on the nature and extent of the Federal Government's role in facilitating and coordinating these actions.

Attendees of the Conference participated in one or more of five task forces organized by Frank M. Richmond, Vice President of Universal Cyclops. The task forces were charged with the responsibility of examining the major critical materials issues and developing an action-oriented set of recommendations for government, industry, and academia. These issues are: research and development; engineering education, manpower, and training; materials availability; institutional and industrial factors related to national materials policy; and materials as a technological force in productivity.

The Conference also featured tutorial papers, plus panel discussions offering the perspectives of government, industry, and academic representatives.

Task Force Conclusions

Viewed collectively, the task force findings point towards two major concerns. One involves the existence of a coherent, continuous, institutional mechanism for coordinating all aspects of national materials policy. The other is the need for increased federal support for programs and activities ultimately aimed at reducing materials vulnerability.

Accordingly, two specific pieces of legislation considered by the 97th Congress were endorsed within the task force deliberations: the establishment of a three-man Council on Critical Materials as provided for by H.R. 4281, and a 5-year extension on the Defense Production Act (DPA) as originally specified by S. 2375. (S. 2375 was subsequently amended and enacted to provide for a six-month unfunded extension of the DPA. For more information on this bill and other materials related legislation, see Appendix C.)

The task force also considered whether their respective issues were adequately addressed by President Reagan's April 5, 1982 re-

sponse to the National Materials and Minerals Policy, Research and Development Act of 1980 (P.L. 96-479). While crediting the President's report as a positive step, most of the task forces concluded that it did not go far enough towards satisfying the directives set forth by P.L. 96-479.

A summary of task force findings and recommendations follows.

MATERIALS AVAILABILITY

According to this task force, the availability of materials for meeting national needs can be promoted in the short term through programs of stockpiling and recycling, and in the long term by a comprehensive materials substitution research program, a sound policy on access to public lands, and a revitalization of domestic mining and processing industries.

To coordinate proper policy towards achieving these goals, the task force supported the establishment of the Council on Critical Materials within the Executive Office of the President, as proposed in the 97th Congress by H.R. 4281.

Regarding stockpiling, the task force stressed that the present stockpile management system is overly susceptible to political and budgetary manipulation. It was recommended that Congress conduct oversight hearings to assess the current National Defense Stockpile system. Such hearings could lead to legislation ultimately providing for: an effective industry advisory committee structure; an assessment of the quality and form of stockpile material as it relates to current use requirements; increased funding (as well as authority to use transaction funds) to enable stockpile management to reach quantity objectives; and ensuring that stockpile transactions be planned to minimize market impact.

Recycling was identified as a positive method of decreasing dependency on strategic mineral imports. The government was urged to initiate a program to identify existing critical materials recycling technologies for use in emergency situations. Similarly, the government should develop contingency plans for the logistics of collecting and utilizing recyclable critical materials in a national emergency.

A review of materials substitution research programs on identified critical materials was called for to evaluate their adequacy in meeting national security needs. The Chromium Substitution Workshop held in October 1982 at Vanderbilt University is expected to develop the type of information and data base needed for other critical materials.

The accelerating decline of the U.S. based metal processing and mining industry was identified as a major problem requiring prompt corrective action. Recommended actions include: reform of environmental regulations, greater governmental efforts to encourage capital investment in mining and related processing industries, a restoration of equity between domestic producers and subsidized foreign competitors, and an orderly and coherent Federal land access policy which would employ a thorough inventory and assessment of Federal land use.

To help revitalize the domestic minerals industry, the task force supported a 5-year extension of the Defense Production Act with

adequate funding to provide market incentives for highly import dependent critical minerals and materials.

RESEARCH AND DEVELOPMENT

This task force pointed out that in the area of minerals and materials, research and development has provided us with a wealth of extractive, process and product technology that has contributed greatly to our standard of living and our defense capabilities. The Administration's plan was viewed as defining the government's responsibility for focusing and directing Federally financed R&D activities on long-term, high-risk technology with the best chance for wide generic application to materials problems. However, concern was voiced about how the prioritization and continuity of R&D activities was to be established and pursued. The need for industry to support research with the expectation of economic return on investment was recognized while the government's role was seen as supporting fundamental research directed toward improving our understanding of mineral exploration, mining, extraction, processing, conservation and recycling. The Committee on Materials (COMAT) was judged to be inadequate for guaranteeing continuity of a long-term R&D materials program and for properly setting priorities in all phases of the materials cycle. An independent body composed of representatives for industry, government and academia was recommended to deal with this function and to provide input to the government on Federally funded R&D programs and opportunities.

MANPOWER, EDUCATION AND TRAINING

Engineering education in the United States was reported to be in a state of crisis. The problem involves a shortage of engineering faculty, increased overcrowding of undergraduate classes, reduction of graduate enrollments among U.S. born students, and the obsolescence of instructional and research equipment in engineering schools. By definition, materials science and engineering (MSE) shares in this crisis.

Recognition of the essential role of materials manpower, education, and training for attaining the nation's goals for materials and minerals was spelled out in the National Materials and Minerals Policy, Research and Development Act of 1980:

> SEC. 4. * * * the President shall, through the Executive Office of the President, coordinate the responsible departments and agencies, and shall * * * Assess the need for and make recommendations concerning the availability and adequacy of the supply of technically trained personnel necessary for materials, research, development, extraction, harvest and industrial practice, paying particular attention to the problem of attracting and maintaining high quality materials professionals in the Federal service.

According to the task force participants, the Administration's response to the Act of 1980 failed to address the perceived crisis in engineering education and the education and training of engineering, scientific and technically skilled personnel. Remedial measures to deal with the manpower, education and training problem include:

Strengthening science and mathematics at the secondary school level;

Improving the technical personnel data base to permit more accurate forecasting of supply-demand requirements;

Increasing support and incentives for junior faculty and graduate students in materials science and engineering, and technician training;

Undertaking an equipment modernization program at engineering schools having obsolete equipment and facilities;

Educating materials scientists and engineers in matters of the interaction of technology, society and public policy; and

Emphasizing industry-government-university cooperative materials and minerals related research programs.

INSTITUTIONAL AND INDUSTRIAL FACTORS

The task force concluded that institutional and industrial factors which impair the development and effective implementation of national minerals policy are: (1) A poorly organized and informed constituency composed of industry, labor and academia, (2) archaic antitrust laws and policies, and (3) inadequate materials related international communication and coordination.

The lack of an informed national materials constituency was traced to the lack of government leadership in this area. What is needed is an effective communications program to furnish the public with the facts about materials problems. Additionally, such areas as international trade, alliance relationships, foreign policy, antitrust restraints, materials education and training, and materials planning continuity must receive further attention in order to forge an effective national materials policy.

The major focus of antitrust legislation has been concerned with competition within the United States. Today, the U.S. faces severe competition in the world market and domestically from foreign industries and even foreign government owned or orchestrated industries. Thus, in light of changing trade patterns and economic conditions there is a pressing need to take appropriate action to modernize antitrust legislation in order to improve the competitive position of U.S. materials industries.

International materials cooperation and coordination would be enhanced by establishing a permanent international materials institution to provide for continuity and ready exchange of information. Areas of special interest include materials research and development, manpower, education and training, supply disruption mitigation, stockpiling, and access to resources.

MATERIALS AS A TECHNOLOGICAL FORCE IN PRODUCTIVITY

The contribution of materials to productivity enhancement was examined from the perspectives of major technological opportunities and key policy issues. Special technological areas requiring added attention are:

Development of quantitative data and models for unit operations and processes of producing materials and fabricating products;

Development of sensor technology and adequately controlling industrial materials processes and end products;

Development of reliable, dynamic inspection systems and life predictive models;

Advancement of computer-aided design; and

Utilization of non-traditional ways of producing fabricating and finishing materials and products such as powder metallurgy, plasma processing and directed energy processing.

Productivity can be increased by incorporating advanced materials in innovative products with large improvements in performance. A number of materials related areas which show high promise are electrooptics and electronics, metastable (rapidly solidified) materials, composites and synthetic polymers.

Materials policies and practices and science and technology policies in general are recognized factors for increasing productivity. For example, Federal R&D policies should strengthen advanced applied research and long-term basic research. Universities need to be coupled more closely to industry, and materials professionals should be educated in fields such as economics, public policy, resource management, production and the management of complex systems.

Tutorial Papers and Panel Discussions

Two tutorial lectures were delivered at the Conference. Hon. Doug Walgren (D-Pa.) offered an analysis of the President's response to the National Materials and Minerals Policy Act of 1980, while Hans Landsberg of Resources for the Future addressed some key elements common to critical materials issues. A pair of panel discussions were then held, dealing with the subjects raised by the tutorial speakers.

TUTORIALS

Hans Landsberg of Resources for the Future stated that "public debate on U.S. mineral policy is on dead center" and is likely to remain there until each of the main issues are evaluated in terms of cost-benefit and other competing societal objectives. His analysis of the President's response to the requirements of the National Materials and Minerals Policy, Research and Development Act of 1980 was put in terms of "cheering those waiting for a friendly word and disappointing those expecting forceful action." In general, Landsberg classified past legislation on materials and minerals policy as acts that set down lofty, general goals but left little imprint. Some other key points discussed by the speaker included:

- Security of minerals supply at reasonably stable prices. Here, supply vulnerability is the short-term concern while supply depletion is given a very long time constant.
- The availability of strategic minerals and materials. International geopolitical policies and possible actions by foreign governments (e.g., Soviet Union) were reviewed and analyzed.

As remedial measures for the U.S. materials and minerals problems, Landsberg proposed emphasis on strategic stockpiling and substitution but also mentioned recycling and expanding domestic production. In concluding his remarks, he dealt with the subject of a comprehensive national materials policy as "an elusive goal at best and a waste of time at worst." This is because he is convinced that it is more useful to deal with individual issues such as stock-

piling, substitution, research and development and access to public lands than to deal in generalities that cannot be forged into a national materials policy.

Congressman Walgren's view of the National Materials and Minerals Policy, Research and Development Act of 1980 differed from that of Dr. Landsberg in that he considered the new law as a "first step in this very complex area . . . intended to establish a comprehensive overview of the problem, as well as to focus attention on the importance of materials issues." The Act required the President to submit to Congress a program plan for dealing with the policies and issues covered in the legislation. His analysis of the President's plan identified a number of shortcomings:

- Overemphasis on minerals supply and mining with too little attention paid to materials processing;
- Lack of priorities and needs in research and development programs;
- Failure to deal with recycling, conservation, and waste materials disposal;
- Absence of a mechanism to permit private sector participation in policy or program development;
- Non-establishment of a materials policy organization within the Executive Office of the President.

To correct existing deficiencies in national materials policy, Congressman Walgren proposed passage of The Critical Materials Act of 1981 (H.R. 4281) which would set up a Council on Critical Materials to oversee and coordinate Federal materials programs. He pointed out that the Administration opposes the legislation as unnecessary.

PANEL ON KEY ISSUES OF MATERIALS POLICY

William A. Owczarski of the Pratt and Whitney Aircraft Division and Chairman of the Nonfuel Mineral Task Force, National Association of Manufacturers, moderated the Panel on "Key Issues on Engineering Materials and Minerals Policy and How to Address Them." Viewpoints from industry, government and academia were aired.

For example, Julius Harwood of the Ford Motor Company discussed some industrial viewpoints on national materials policy. He questioned the crisis-like atmosphere that has permeated discussions of national materials policy, critical and strategic materials and minerals dependency and vulnerability. Harwood asked, "What inhibits the ready establishment of needed policy and implementing actions?" He concluded that an essential part of national materials policy involved the individual and aggregated actions and internal policies of the industrial sector. Starting in 1974 the concept of materials management was recognized in industrial organizations and took on new dimensions as it encompassed all technical and business decisions related to the flow of materials. The automobile industry was identified as a consumer oriented materials using and fabricating industry that was capable of influencing a basic materials producing industry (steel) to produce new classes of steel.

Harwood discussed the concept of degree of materials criticality-vulnerability index within the context of minerals and materials vital to the national well-being as it applies to industrial and eco-

nomic vitality. Criticality here applies to product design, functionality, product performance and cost. The degree of vulnerability is evaluated in terms of options or trade-offs. The industrial materials vulnerability index would be related to materials of special importance to a particular industry. He cautioned, however, that "dependency need not be equated with vulnerability." Like Landsberg he identified materials substitution as a means of dealing with materials shortages. The key here is close cooperation between government and industry and participation of the technical community.

Remarks by John W. Goth of AMAX Molybdenum Division identified access to public lands, the national stockpile, and the Federal role in materials R&D as the key issues for a national materials policy.

Concerning public lands, Goth maintained that a materials policy should contain specific provisions which assure that access will be available for as long as is needed to document and inventory the nation's mineral reserve.

With regard to the stockpile, he stressed its importance to national security, but added that "these stockpiles should be given careful stewardship and their use should not cause economic disruption or inflict hardships on the domestic industry."

Finally, Goth urged a greater Federal role in materials R&D for areas where there is no economic incentive for industrial research. He emphasized fundamental research for materials substitution as an example.

Another industrial view of materials availability, including the national stockpile, was given by James A. Ford, Director of Engineered Products, Cabot Corporation, who proposed a private sector stockpile of critical and strategic materials. Under his plan, companies would increase their normal inventory to take into account Federal requirements under national security emergency conditions. He proposed a government-industry-academia management advisory team to help deal with the management aspects of the national stockpile which he felt needed strengthening. Other strategies for making critical materials more available in time of need should be explored, said Ford, especially such options as research and development, recycling and substitution.

According to Paul Wynblatt, of Carnegie-Mellon University, academia has two avenues for addressing problems related to materials and minerals policy: education and research. He provided an overview of technology policy academic programs, and discussed the nature of technology policy research performed by universities.

Finally, a special presentation was given by J. B. Clark, Assistant Director, National Physical Research Laboratory of South Africa on the strategic resources of southern Africa and trends towards export in alloy form. He also emphasized that South Africa could be depended upon as a continuing supplier of critical materials to help meet U.S. needs.

PANEL ON PRESIDENT'S RESPONSE TO PUBLIC LAW 96-479

Stan Margolin, of the Arthur D. Little Company and past president of the Federation of Materials Societies, led the panel discussion on responses to the National Materials and Minerals Policy, Research and Development Act of 1980. Representatives from the Executive Office of the President (COMAT), the Department of De-

fense, Department of Interior, and the Federal Emergency Management Agency discussed the accomplishments to date under the President's materials program plan.

One of the speakers, Robert C. Horton, Director, U.S. Bureau of Mines, stated that the Administration's National Materials and Minerals Plan will help strengthen the mineral economy of the United States. In his words, "the plan signals the commitment to reduce the nation's dependence on foreign sources of minerals and to promoting a healthier domestic minerals industry." It is the first such commitment from a President in nearly 30 years, he stated. The plan calls for opening more public lands to mineral exploration, identification of burdensome regulations, strengthening ties with western nations, revitalizing the strategic stockpile program, and providing Federal support for long-term, high-risk, high-payoff mineral research projects. Horton described steps being taken within the Bureau of Mines to implement the President's policies.

Paul Krueger, Assistant Associate Director of the Federal Emergency Management Agency [FEMA] provided an informative discussion on a number of stockpile issues. This subject has not been publicly discussed by government officials from the FEMA at meetings such as the Harpers Ferry Conference and much of what he said about the stockpiling process, Federal operating practices and current problems provided the audience with a valuable perspective. For example, the need to balance projected national emergency requirements against real free-market forces and the availability and management of stockpile funds was discussed. In the course of the Conference, he also discussed problems related to priority setting, government purchasing practices and potential market disruptions.

Murray Schwartz, of the Office of Science and Technology Policy, discussed OSTP's role in implementing the President's National Materials and Minerals Program Plan. Schwartz outlined the structure and function of the newly reaffirmed Committee on Materials [COMAT], which will develop a data base on Federal minerals and materials R&D by conducting a complete inventory of agency projects. He emphasized that the establishment of COMAT, along with the Cabinet Council, insures high level consideration and adequate coordination of minerals and materials issues within the Executive Branch.

Richard E. Donnelly, from the Office of the Under Secretary of Defense (Research & Engineering) described DOD efforts to reduce strategic and critical materials vulnerability. Donnelly described a DOD study which examined supply and demand in terms of DOD requirements, supply sources, and industrial capacity. Major technical options—such as exploration, conservation, recycling, and substitution—were identified to meet these demands.

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STRATEGIES FOR COPING WITH CRITICAL ISSUES RELATED TO ENGINEERING MATERIALS AND MINERALS

Proceedings of the Seventh Biennial Conference on National Materials Policy, Organized by the Federation of Materials Societies for the United States Congress with Participation by the Congressional Research Service, the General Accounting Office, and the Office of Technology Assessment

Allen G. Gray—Conference Chairman

Held in Harpers Ferry, West Virginia, July 19–22, 1982

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I. INTRODUCTORY SESSIONS

Charge to the Conference*

Ladies and Gentlemen. On behalf of the Federation of Materials Societies and the fourteen affiliated technical and professional societies representing more than 500,000 members, I want to welcome you to the Seventh Biennial Conference on National Materials Policy. The central theme of this conference deals with strategies for coping with critical issues related to engineering materials and minerals. During the course of the conference we will define the key elements of these critical materials issues, review the status of existing legislation and the response of the Reagan Administration to the requirements of the National Materials and Minerals Policy, Research and Development Act of 1980, examine what of significance has been accomplished thus far to resolve our materials and minerals problems, and determine what still remains to be done in dealing with these critical issues.

It should be mentioned that this conference follows in the pattern established in the previous six conferences held in Henniker, New Hampshire, but it is the first one sponsored by the Federation of Materials Societies. The influence of the Henniker Conferences on national materials policy has been profound for it not only promoted public review and debate on critical materials issues but led to government action in the form of legislation and executive response. We see the present conference as one that serves the public interest and will provide an agenda for action based on the recommendations developed by the participants.

The first day of the conference will be devoted to tutorial lectures, reports and the organization of Task Forces consisting of conference attendees. Session One is concerned with the "Key Elements Common to Critical Issues on Engineering Materials and Minerals" and will provide an overview of national materials and minerals policy and a strategy that effectively addresses the major problems and issues. Following the lecture by Dr. Hans Landsberg key representatives from industry, government and academia will address these issues from their particular perspective. In the afternoon, Session Two will deal with the "Current Status of National Materials Policy—What Has Been Accomplished Thus Far." Congressman Doug Walgren will discuss his view of the President's response to the Materials and Minerals Act of 1980 and additional needs that require attention. He will be followed by representatives from the Departments of Defense, Interior and Commerce and the Office of Science and Technology Policy who will explain the Administration's response to the Act of 1980. After dinner Dr. Frank Richmond will convene Session Three which will be involved with

* By Emanuel Horowitz, First Vice President, Federation of Materials Societies.

the organization of the five Task Forces and the development of terms of reference. These Task Forces, which will meet concurrently all day tomorrow (Sessions Four and Five), will deliberate on the following issues: Task Force One—Research and Development, Task Force Two—Manpower, Education and Training, Task Force Three—Materials Availability, Task Force Four—Institutional and Industrial Factors, and Task Force Five—Materials as a Technological Force in Productivity. I urge each of you to sign up for the Task Force in which you and your organization have a major interest. One of the principal products of this conference will be the Task Force reports and recommendations and their quality rests largely in your hands. This is an opportunity for representatives from industry, government and academia to work together on developing a position on these critical issues that can be used in the decision-making process by those who formulate and carry out national materials and minerals policy.

On the final day of the conference, during Session Six, each Task Force Chairman will present the Task Force Report paying particular attention to the specific recommendations. Comments and critique from the audience will be encouraged. For those who have managed to survive this process Session Seven will be available for wrap-up discussions and summary.

The Federation plans to publish the proceedings of the conference including tutorial lectures and Task Force Reports. There is much work to be done in the next three days, and I wish you well in your endeavors.

Introductory Remarks by the Conference Chairman: Significance of 1982 Conference on National Materials Policy *

As Chairman of this Seventh Biennial Conference on National Materials Policy, I would like to add my greetings to those you have received from Dr. Horowitz and say that the Federation of Materials Societies welcomes your participation in the deliberations and discussions of this conference.

Before commenting briefly on the background of the series of previous conferences on National Materials Policy, generally known as the Henniker Conferences, I believe we can say that the perspective for this conference has an enhanced significance. It is the first one that has the opportunity to consider as a part of its deliberations, legislation passed by the Congress on National Materials Policy. As most of you know in October 1980 Congress passed the National Materials and Minerals Policy, Research and Development Act of 1980 and it was signed into Public Law 96-479.

On April 5 this year, as called for in Section 5(a) of P.L. 96-479, President Reagan transmitted to the Congress the "National Materials and Minerals Program Plan and Report to Congress." This high level attention to the plight of this nation's materials and minerals situation provides a basis for assessment and evaluation of what has been accomplished thus far. This is a new challenge for the Conference in its deliberations. Even so, this year's Conference

* By Allen G. Gray, Technical Director, American Society for Metals; Adjunct Professor, Materials Engineering and Management of Technology, Vanderbilt University.

can reflect on the fact that this is the first administration in thirty years to issue a key statement on the importance of materials to the economy and to the nation's security.

As I noted earlier the conferences on National Materials Policy were initiated in 1970 with certain purposes in mind.

One was to keep the issue of National Materials Policy alive, and to remind public interest groups and decisionmakers of its importance.

A second purpose was to sustain progress toward the design and development of a national materials policy.

A third objective was to build a consensus on the essential elements that should comprise a national materials policy.

Another objective was to convey to national decisionmakers in the legislative and executive branches of the Federal Government a true perception of this emerging consensus.

Looking into the background of previous conferences, we should note that the first conference, in July 1970, warned of future difficulties and urged a balancing of policies for materials, energy, and environment. In the following October, the Congress adopted the Act creating the National Commission on Materials Policy.

The second conference, in 1972, had active participation by the Chairman and staff of this Commission. This conference explored key issues that were later to constitute the gist of the Commission's final report. It stressed the need for a cooperative interaction among government, academia, and private industry.

The third conference, in 1974, stressed the need for reliable and accessible information on all aspects of Materials Management. The staff of the National Commission on Supplies and Shortages contributed substantially to this program.

The fourth conference in 1976 was built around the theme, "Engineering Implications of Chronic Materials Scarcity." The conference did not attempt to document the prospect of scarcities, but sought to define the engineering implications of persistent unbalance in supply, arising from shortages of energy and requirements of environmental quality.

The fifth conference, in 1978, returned to the question that was considered in 1970, and was titled, "Building a Consensus on Legislation for a National Materials Policy." It dealt with the importance of a national policy in terms of sponsorship of research; in terms of information management; in the opportunities for federally supported technological innovation; and in a sustained and continuing analysis of trends to anticipate and forestall future crises.

The sixth conference, in 1980, stressed the need for new initiatives in promoting technological innovation in the basic materials industry.

As you can surmise these conferences have become a biennial institution to develop ideas on how the industrial sector, academia, and the Federal Government can work together effectively in a number of important areas that have a bearing on national materials policy.

As I pointed out earlier, this seventh conference, although continuing the tradition established by the previous six conferences, takes on new significance because of the perspective provided by the enactment of national materials policy legislation, and the op-

portunity to assess the response to the legislation in terms of what has been accomplished thus far, and provide recommendations on what remains to be done.

Unlike more conventional forums, the conference is designed to encourage free participation by all attendees and to promote dialogue on the topics of the meeting. It is intended that all participants will contribute actively to the development of recommendations in the issues to be considered. Finally it is most appropriate that we should recall that these conferences were largely the creation of Dr. Franklin P. Huddle, who initiated the first conference in 1970 in response to congressional concerns and was actively organizing the sixth conference at the time of this death on May 30, 1980. The sixth conference held shortly after his death was dedicated as a memorial in honor of his leadership and the many contributions he made in promoting a national materials policy. I'm sure many of you who knew Frank feel the same deep personal loss that I do and also reflect on how meaningful it would have been if Frank had been around to experience the passage of the National Materials Policy legislation. I should also note that a close associate of Frank, L. Harold Bullis, who was unable to attend the conference, provided valuable help in structuring this program.

As noted in the proceedings of a previous conference, a materials policy must respond to the changing times, and indeed anticipate them. No better way to do this in a free society has been found than by the free exchange of views among informed persons in an open forum of discussion.

In this year's conference we should recognize and assess the progress we have made, even though as many have stated: this may be only the beginning toward what is needed. Because of the legislative activity since the last conference, we have more issues and real "meat" to sink our teeth into than in previous forums on national materials policy.

Now it is my distinct pleasure to present your Chairman for the morning session, Dr. John B. Wachtman Jr. And I am going to do just that, because it has been a tradition in the Henniker Conferences that introductions be minimized. Dr. Wachtman is Director, Center for Materials Science, National Bureau of Standards. He was Chairman of the 1976 National Materials Policy Conference. We are pleased that Dr. Wachtman can chair this important opening session.

II. TUTORIAL PAPERS

Tutorial Lecture: Analysis of the President's Response to the Materials and Minerals Act of 1980*

I am pleased to appear before this distinguished group to offer some thoughts concerning strategies for dealing with critical issues related to materials and the formulation of a national materials policy. I would note at the outset that Congress and in particular the Committee on Science and Technology on which I serve has had a long standing and on going concern for materials questions for better than a decade. For example, our Committee has published the proceedings of these materials policy conferences since their inception, giving you some indication of that interest.

1980 NATIONAL MATERIALS ACT

As pointed out recently in another forum by the Chairman of our Committee, the Honorable Don Fuqua, the Science Committee's emerging concern was translated in the last Congress into the first major statement on materials policy in over three decades, Public Law 96-479, the "National Materials and Minerals Policy, Research and Development Act of 1980," originating in our Committee and signed into law, requires a number of steps to be taken by the President in addressing materials problems. The new law was seen as a first step in this very complex area and was intended to establish a comprehensive overview of the problem, as well as to focus attention on the importance of materials issues. It was never seen as a general solution to these problems, but simply as a means—a first step—in addressing them.

PRESIDENTIAL MATERIALS PLAN

The 1980 Materials Act, among other things, called for the President to submit to Congress a program plan for dealing with the policies and issues outlined in the law. On April 5th of this year, some six months after it was actually due, such a plan was finally provided to Congress. The plan has been hailed by this Administration as "The first such Presidential commitment in nearly three decades." I would quietly note that I doubt that the passage of Public Law 96-479 requiring such a plan, and the plan itself, would ever have evolved without the persistent pressure of Congress and others like yourselves.

In late April our Committee held two days of hearings to evaluate that plan and to consider further legislative steps that may be necessary. Let me share with you a few of the facts we gathered at those hearings.

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*By Hon. Doug Walgren, Congressman from Pennsylvania.

OUTLINE OF PRESIDENT'S MATERIALS PLAN

Briefly stated the President's plan for materials focused primarily on the minerals and public lands policy to promote domestic production of industrial minerals. The materials plan proposed actions on:

1. *Federal Lands availability,* looking to ways of opening public lands for minerals development;
2. *Minerals data collection* to monitor supply and demand needs;
3. *Research and development* policy which focused primarily on the role of the private sector, with Federal support of "long-term, high-risk technology;"
4. *Regulatory reform* of such "excessively burdensome or unnecessary regulations . . . which adversely affect the domestic minerals industry;"
5. *Stockpile policy* focusing on upgrading stategic minerals and materials through necessary appropriations; and
6. *The Cabinet Council on National Resources and Environment* in which coordination responsibility was placed.

PROBLEMS WITH PLAN

Though seen by many as a sensible statement of policy and a "step forward for the minerals industry," our analysis of the present plan brought to light a number of problems:

The focus on minerals and mining missed a more balanced and comprehensive approach that would incorporate materials processing and use. For example, the Department of Defense requires finished products with specific properties, not simply raw materials.

Though R&D is recognized as an important policy element, no new steps are taken to identify priorities and needs, to assess public and private programs, and to establish an effective means of coordinating Federal materials R&D programs.

The need for greater attention to strategies of resource recovery, conservation, recycling and waste materials disposal is totally lacking.

The program plan targets no monies for expenditure even though the original law calls for identifying specific expenditures and programs.

No provision is made for private sector participation and consultation in policy or program development, nor for sufficient means to properly collect, analyze and disseminate critical materials or minerals information.

No provision is made for long-range assessments of minerals and materials needs in the 5, 10, and 25 year outlooks as specifically required.

Finally, though the Cabinet Council is designated as responsible for overall policy guidance and coordination, the establishment of a permanent organizational entity within the Executive Office of the President as required by the law is sidestepped.

FAILURE IN POLICY

More than anything else, in evaluating the President's materials plan, what we see is a major failure in policy and policy direction. Where we called for a balance between materials, energy, and environment, we see a overwhelming shift to supporting minerals and mining while ignoring the effects in these, and other policy areas. Where we called for a comprehensive view of the entire materials arena we see a myopic emphasis on supply, with no concern with final processing or consumption. Where we called for assessing long term needs in such areas as research and development, manpower education and training, and changing critical materials demands, we see no long term assessment or coordination.

THE CRITICAL MATERIALS ACT

The failure of the Administration's materials plan brings Congress back to the position it held a year ago when Chairman Don Fuqua, myself and twenty-two other Members co-sponsored H.R. 4281, "The Critical Materials Act of 1981." We see this as the logical next step in moving toward a comprehensive materials policy and implementation of such policy. As presently written, the bill calls for a three member council on critical materials to be established within the Executive Office of the President.

The Council would have the responsibility to oversee and coordinate the multitude of Federal materials programs. In materials research alone there are over 14 agencies and departments involved with a funding level of over $1 billion. As envisioned, the Council would act as the focal point for analyzing and evaluating materials policy in conjunction with other national policies.

Special emphasis would be placed on establishing and carrying out a broad, national R&D program to assure proper investment in the Nation's future as well as in present materials needs. One such program outline being advanced, by Dr. James Williams of Los Alamos National Laboratory would focus on (1) resource assessment; (2) materials science and technology; (3) advanced materials processing technology; (4) conservation and recycling; and (5) systems analysis. A policy orientation toward research, new technologies, and new materials would provide the Nation with a *positive* set of actions and initiatives in lieu of what I perceive as a stagnant *reactionary* policy focusing only on our minerals vulnerability.

The council would have to integrate any materials policy with other Federal policies, as well as with individual elements of any specific material-related action. The Council would also have to establish necessary consultative ties to the outside community, an element now sorely lacking by the present Cabinet Council. All of this sounds like a monumental task for only a three-member Council. It may prove to be so. However, our intent here is to avoid creating an unwieldly bureaucracy that would impede effective action on critical materials. Our goal was and is to provide sorely lacking coordination at a sufficiently high level. The structure outlined is not intended as an absolute arrangement, but more as a starting point for further discussion.

Reaction to our proposal, while not overwhelming, has been very positive. All of the outside witnesses to our hearings this year and

last have endorsed our overall, as well as more detailed, strategy. This included such diverse groups as the high technology and basic materials industries, academia, the minerals community, and environmental groups such as the Audubon Society. Not surprisingly the Administration opposes the legislation, with OMB taking the position that is unnecessary. They state that present needs are met by the Materials Policy Act of 1980 which they also opposed. Oddly enough, Joseph Wright, now Deputy Director of OMB, stated last February in a materials colloquium and while still Deputy Secretary for Commerce that what was essential and now lacking was a *comprehensive means for coordinating national materials policy.*

Our position at present is to proceed with the bill. The Subcommittee on Transportation, Aviation and Materials of our Committee has scheduled markup of the bill next week and I fully expect the bill to be favorably reported out of full Committee in the near future. Chances for final passage and enactment, though not overwhelming, are not entirely bleak either.

CURRENT PROBLEMS—THE STEEL INDUSTRY

Before closing I would like to mention briefly a current problem which as a Congressman from Pittsburgh is dear to my heart as well as to my constituents. I am referring to the Nation's preeminent basic materials industry—the steel industry.

As I am sure you are all aware a healthy steel industry is basic to this Nation's defense and economy. But healthy it is not. Operating rates have dropped to below 50 percent. Imports have risen to over 26 percent. Recent employment figures show that over 100,000 or 35 percent of steelworkers are laid off and unemployed. In Pittsburgh that percentage is even higher. When an industry like steel declines, that decline reverberates through the community. A rule of thumb is that every factory job is backed by two or three support jobs. Layoffs and cutbacks mean less consumer purchasing. People out of work means a bigger drain on public resources—unemployment compensation, food stamps and so forth—and therefore a higher Federal deficit. For every one percent of national unemployment, the Federal deficit is raised by roughly $20 billion. Thus steel's problems are community and public problems particularly in those areas where steel production now predominates.

As a result of the 1980 Materials Act the Department of Commerce has announced that it will now focus its attention on a study of critical materials affecting the steel industry. Welcome as such policy attention is, I don't believe we really need another study of the steel industry to begin acting. If we study it enough and take no action we will literally study the industry to death.

In the short term we must deal with unfair subsidization of foreign imports and subsequent effects on our competitiveness. In the long term we must deal with the lack of comprehensive investment by the steel industries in new, innovative technologies and facilities. This type of investment will require a concerted and committed effort by the Federal Government to provide incentives for the industry to reinvest in its basic technology. What is lacking in the United States—unlike in other nations—is a coordinated and well understood policy and consensus concerning the critical importance

of a strong domestic steel industry. I believe the Critical Materials Act would take a good step in this necessary direction.

OTHER LEGISLATIVE PROPOSALS

I would note here that there are a number of related materials and minerals policy-oriented pieces of legislation now before Congress. Many of these focus on specific areas or issues such as strategic stockpiling or wilderness area designations. Others are more broadly based, such as the reauthorization of the Defense Production Act (H.R. 5540), scheduled to come to the floor shortly, and the National Engineering and Science Manpower Act of 1982 (H.R. 5254) now being considered by our Committee. All of these can or will have specific, and perhaps far reaching effects, on materials and materials policy in this country. This underscores I believe the necessity for at least some attempt at the comprehensive approach we are proposing.

SUMMARY

To summarize, it is obvious that we are dealing with an extremely complex yet very important issue. Materials and their production is key to our national economic and defense needs. In terms of developing a national policy, it has taken us well over 30 years to arrive at where we are now and still there is no real end in sight. I think we have learned that the problem must be viewed as a whole and in a comprehensive manner. Yet such an overview should not be to such a degree that we are paralyzed into inaction, but should be in a way in which we can effectively handle discrete and, hopefully, "digestible" bits such as materials R&D, the steel industry, and so forth.

Finally, it is important that such policy be designed for continuing evaluation and change, with specific emphasis on interfacing Federal direction and goals with those of concerned private and public enterprises. It is here where I see the importance of such experts as yourselves in deliberations such as this conference to help us set the proper course.

TUTORIAL LECTURE: KEY ELEMENTS COMMON TO CRITICAL ISSUES ON ENGINEERING MATERIALS AND MINERALS*

Concern over adequacy and reliability of mineral supplies has a long tradition in the United States; but successive forecasts of impending scarcities if not disaster have all proved wrong. Numerous governmental commissions have investigated the matter and have generally concluded that, while there are problems, there are also means of coping with them.

Most recently, largely in the wake of the 1973/74 oil embargo, the steep upturn in energy prices, and the outpacing of additions to domestic oil and gas reserves by depletion, new aspects of a threatening "running out" have come to the fore, made more complex by the fact that substantial portions of some key materials reach this country above all from Southern Africa and the Soviet Union, two

*By Hans H. Landsberg, Senior Fellow, Resources for the Future, and Joint Director, RFF/Penn State Mineral Economics and Policy Program.

parts of the world considered as potentially unreliable or unstable sources of supply. When you add this to conventional elements of market instability, you need not look far to identify issues and problems.

There is no dearth of legislation either, though of little operative force, nor lack of suggested remedies. Among them, easing restrictions on access to Federal lands, substantial relief from environmental regulation, improved stockpiling, fiscal and other financial incentives to industry, greater government aid to research and development, and, in some poorly defined way, a greater "recognition" of the valuable role played by minerals producers.

My presentation will try to sketch in some of the details of the major problems and remedies so as to provide a backdrop for the more specific topics to be ventilated at the conference. Naturally, I must be selective. Thus I shall concentrate on the minerals and on those issues that currently are in center ring. This limitation may be regrettable but though we have all morning, there is a six-man waiting line behind me, and we should leave plenty of time for questions from the floor.

For those of you who, like me, are either puzzled or turned off by the term "tutorial," let me start by assuring you that I am not at this spot to deliver a lecture nor, in any way, attempt to tutor anyone, least of all an assembly of specialists. And to show that I mean what I say I shall begin with a most untutorial and unscholarly assertion. That is, the public debate on U.S. mineral policy is at dead center. Moreover, it is destined to stay there unless those participating in it shed their ideological trappings and in a cool and detached manner take one issue at a time and evaluate its various aspects with regard to costs and benefits, real and perceived, with regard to its relationship to other societal objectives, with regard to both short- and long-term national survival, and a host of other considerations.

Unfortunately, as of now the debate is conducted in a highly adversarial form, in which each side not only claims to be in possession of the truth but accuses the opponent of various sins among which bad faith is the least. Thus in arguing over the future of the public lands the charge of "locking up the nation's mineral wealth," conventionally thrown at environmentalists, is matched in silliness by the charge phrased by the opposite camp of "ripping up the entire nation west of the Mississippi." It is my conviction that this kind of rhetoric does not reflect the real world nor is it apt to settle policy. It is, however, a powerful poisoner of the intellectual atmosphere, and there are no signs that the level of intensity is dropping.

In this context I am pleased that I have been asked by your organization to place the issues, as I see them, before you, since I consider myself a member of neither camp. I am not what one might call a materials fundamentalist nor an environmental advocate. People who consider themselves "above the battle" often are dull by comparison with those engaged in it. If this is the price of objectivity I will have to pay it, and so will you, listening to me.

COMMISSIONS

As I have said, concern over materials adequacy—and that is overwhelmingly minerals adequacy—is not a recent phenonmenon. It has come and gone as supplies have tightened or eased and prices have risen or fallen. Let me limit my purview to the past three decades which takes me conveniently to 1952, the year the President's Materials Policy Commission—or Paley Commission for short—released its findings. The report still remains a milestone in analysis of the nation's resources, and materials had a prominent place in the Commission's scheme. It courageously estimated future demand thirty years in the future, looked at resources to meet that demand, and analyzed the chances for adequacy. In a way, it set the tone for many similar subsequent ventures. It also assessed policy options, came out squarely for obtaining supplies where they cost least, compatible with national security, and advocated reliance on national stockpiles as the primary means of security. I believe the Commission also was the first to note the lack of a focal point in government, where the strands of materials policy come together. Its proposal to mold the National Resources Planning Board into a policy body not only failed, but not long after the report was released the Board was abolished. In retrospect that was probably a bad mistake. For it condemned the country to episodic "analysis by commission."

The Commission's projections for the year 1980 turned out to be off the mark. Whose wouldn't? But the Commission deserves credit above all for two items: one, it insisted that the notion of "running out" of resources was a misconception. Rather, one must think of rising costs and prices, with their impact on both demand and supply leading to a new equilibrium. Secondly, as I have mentioned, it suggested that a striving for resource independence would burden the economy with high costs to the disadvantage of its international competitive position. I believe both are considerations as valid today as they were thirty years ago.

The 1950's and 1960's were not marked by pressing national materials problems, and the recommendations of the Paley Commission found no eager advocates. In the meantime, beginning halfway through the sixties, the environmental problem added a new dimension to the agenda of public concerns, and while minor compared to energy as a producer of pollutants, materials were involved on the production side by way of effluents from smelting and refining and on the consumption side by the generation of scrap. The National Materials Policy Commission, established by Congress and reporting in mid-1973, was thus heavily oriented toward assessing the trade-off between materials and environment as evidenced in the report's title "Material Needs and the Environment." Like the Paley Commission, it favored procurement at least cost with due regard for national security and, going with the times, with adequate protection of the environment. It also called for creation of a "comprehensive Cabinet-level agency" that would look after materials, energy and the environment. Its recommendation in that respect got no further than did that of the Paley Commission.

It took only a little more than a year for Congress to set up yet one more Commission, the "Supply and Shortages Commission" established in September 1974. Its creation was motivated by a sizable number of actual shortages, not just of materials, that coincided both with the beginning of the energy problem as well as with the "Limits to Growth" syndrome, dramatically described in the 1974 bestseller of that name. The Commission reiterated and, if anything, sharpened the views of its two predecessors in deflating the twin ideas of "running out of resources" and subsidizing or protecting domestic production. It differed sharply in its view on concentrating policy in the government. In fact, it was probably the first to question whether there was such a thing as a "materials policy," a point I will return to later on.

The Supply and Shortages Commission was emphatic in suggesting that the marketplace was the most efficient tool for equating supply and demand, a viewpoint highly in tune with the basic philosophy of the current administration but that endeared this particular document to neither the mining industry nor to contemporary mineral policy makers. As is usually the case, being subject to the operation of the marketplace is something you wish on the fellow next-door.

LEGISLATION

Policymaking, or some might say, policy evasion, by commissions has had its parallel on Capitol Hill. The Mining and Minerals Policy Act of 1970 and its successor, the National Materials and Minerals Policy, Research and Development Act of 1980 are full of brave words and fine sentiments. But, with some exceptions, especially in the 1980 Act, they fail the test of specificity. It simply is not enough to call for a "healthy minerals economy" or "the orderly and economic development of domestic mineral resources," to caution about "due regard for national security and the environment", and to utter similar well-intentioned, non-operative phrases. Yet, this has been the substance of legislation. Only in one respect did the 1980 Act go into specifics. It named the Executive Office of the President as the governmental location where materials problems would come together, policy would be hatched, and a variety of tasks be undertaken. In its long frustration over the absence of an "ear" and a "voice" in high places, the Congress, following the cues from the appropriate committees set down a large number of tasks to be performed by the Executive Office, ranging from reports to be submitted to the Congress (the first of which was released in April 1982) to specifying the areas in which governmental activity is called for, e.g., support for R&D in exploration, discovery, and recovery; enhanced production processes; greater conservation of materials; dissemination of information; a continuous assessment of policies that can affect the materials cycle, etc.

How to go about all this, what tradeoffs to make, where initiative and funding are to be located, etc. is not spelled out in either of the Acts. All we find are general declarations of intentions, without a clearly articulated notion of the Federal Government's role and the resources to be devoted to it. Given budget constraints and the

more limited notion that the current Administration holds of the governmental role (as obvious, for example, in the approach to energy R&D) it is difficult to see that there will be much movement. The President's report of April 1982 bears this out. I think it would be fair to say that it has cheered those waiting for a friendly word and disappointed those waiting for forceful action. Granted, it is only a policy plan and the result of much give and take among the agencies involved, still one would have welcomed a batch of fresh initiatives.

Before concluding this quick review of the public policy arena, let me mention two bills that have been pending for some time and deserve at least mention, even though they now have virtually no chance of becoming law. One is the Critical Materials Act of 1981 which relentlessly pursues the idea of a "voice in high places" and calls for a "Council on Critical Materials" in the Executive Office of the President. If you guess that what this Council would do mostly is to "coordinate" you guess right. The second legislative effort is Representative Jim Santini's National Mineral Security Act of 1981. It is noteworthy, above all, for a courageous attempt to make progress in the thorny area of public lands by suggesting that individually promising sites be nominated by industry and then reviewed for their suitability for exploration. As I shall discuss later, some such move might get us away from the "battle of aggregates"—of numbers, that is—that, it seems to me, gets us nowhere. Of course, nothing guarantees that the contenders on both sides of the issue would go for a site-by-site approach.

So much for major policy initiatives over the past thirty years. If one leaves the table rather hungry, as I do, one tends to wonder why. I can offer two reasons: legislation that limits itself to setting down lofty, general goals is not likely to leave much of an imprint. Government agencies have their hands full with complying with myriads of specific directions and regulations decreed by Congress and are likely to let the job of breathing life into general exhortations drop to the end of the line. Secondly, none of these acts have been coupled with appropriation of funds. Non-regulatory, non-funded legislation is apt to live mostly in file cabinets. The 1980 Act at least called for reports as an action-forcing tool, but the first of these, the above-mentioned President's April 5th report, appears to me to suffer from the very same deficiency as does the Act that called for it: the prevalence of broad generalities. I say this regretfully. One illustration must suffice. What is one to make of the report's statement of government's role in the all-important area of R&D? Having declared that the government must focus on "long-term, high-risk, potentially high-payoff technology that has the best chance for wide generic application," the President's message goes on as follows:

"To fulfill this role, the Administration will:

(1) Create a business and political climate which will encourage private sector research and development;

(2) Stimulate constructive coordination between industry and government in the area of technological innovation; and,

(3) Focus and direct other government-financed research and development activities on long-term, high-risk technology with the best chance for wide generic application to materials prob-

lems." This hardly qualifies even as policy planning or programming.

SOME USEFUL FACTS

Let me switch gears at this point and move to a consideration of a few basic facts of the U.S. minerals position, and then to some major issues. I will run through the former rapidly not because they are unimportant but because they lend themselves easily to quantification.

1. Non-energy minerals do not loom large in the country's aggregate production of goods and services. In 1980 metallic and non-metallic minerals output, at the mine, was valued at $25 billion. Of that amount, the metallic minerals—the core of concern—accounted for $9 billion. In contrast, the value of oil production was in the neighborhood of $100 billion, natural gas around $30 billion, coal approaching $25 billion. (Table I).

2. When we narrow our focus to the metallics, iron and copper represent 70 percent of the value of all metallics, and neither of the two is in the center of concern. Of the remainder, none but molybdenum is produced at an annual value of more than half a billion dollars. We use that much oil in a single day, produce as much in two days.

3. When it comes to foreign trade, net imports of energy in 1980 cost us $75 billion, of non-energy minerals only $3 billion, and then only because the category includes semi-fabricated products. Excluding these produces a net export balance (Table II). The cost of a day's petroleum imports equals the cost of two years' tungsten supply, or half a year's cobalt consumption. On a world scale the picture is the same: aggregate trade in ores, concentrates and scrap amounts to about 1 percent of world trade; fuels to between 15 and 20; and again, iron and steel dominate the non-energy minerals.

4. There is no agreement what mineral deserves the label "critical" or "strategic," or what the difference is between them. Consequently, some people talk about four, others about 40 minerals to fit one or the other label, though we all are aware of the elements that enter into the judgment. They include as a minimum—

Low degree of technical substitutability;
Limited opportunities for cutting applications;
High share of supply from vulnerable sources;
Poor prospects for raising domestic production at reasonable cost;
High amount of damage from supply failures.

Shaping these factors into an operable judgment has proved difficult but needs to be pursued. The alternative of generously awarding the "strategic/critical" designation will make coping with the problem seem more difficult and costly than it need be.

5. The United States has always been import-dependent for a sizable number of important minerals, such as tin, cobalt, bauxite, chromium, nickel, manganese. For a few, dependence has grown, such as iron ore (which the steel industry likes to import since it is higher grade and cheaper). Still others have had their ups and downs, such a zinc, copper, lead (the last in 1980 on a net export basis). On the whole, import dependence has increased, but neither

consistently nor spectacularly. Unfortunately, a new dimension, namely the move of primary smelting and refining capacity to other countries, increasingly detracts from the value of these statistics (Table III).

6. Compared to its European and Japanese allies the United States is well-endowed with minerals. No U.S. policy can be considered viable that ignores economic and political alliances and relationships.

7. The major portion of this country's mineral imports comes from stable, basically friendly countries located, with the major exception of Australia, in the Western Hemisphere, i.e., Canada, Mexico, Brazil, Venezuela. According to the Bureau of Mines, of 53 minerals imported by the United States, Canada supplies 20 (accounting for one-third of the value of U.S. mineral imports), Mexico 12, Australia 8.

I believe that keeping these orders of magnitude and patterns in mind constitutes a potent barrier to cataclysmic thinking, and, above all, should make one hesitate to see the minerals problem through the prism of the energy problem. Those who, nonetheless, equate these situations do so, I believe, because they think not in incremental terms but in absolutes, black and white. How, they ask, could this country continue to function, if it were deprived of its supply of cobalt, chromium, manganese, what have you?

Posing the question that way makes little sense, nor does the answer. If economists have contributed a useful concept, it is that what matters is *what happens at the margin:* how much does the next unit cost, not what is the value of total supply. Thus, the consequences of supply interruptions or denials work their way slowly, incrementally, giving users and the economy a variety of ways to adjust. To be sure, all of them have a cost, else the adjustments would have been made before. Some of the cost will be explicit and direct, some will be indirect (e.g., poorer performance of a tool). But none are likely to plunge the nation into disaster. Not even the 1973 oil embargo did that.

MAJOR ISSUES

What then are the realistic issues? I would name as my top choice:

Security of minerals supply at reasonably stable prices; and derived from it I would then ask: what is the optimum insurance policy I can take out against the contingency of future massive supply perturbations?

To answer that question one would have to have good information on two scores: the odds on occurrence of the contingency and the damage if it does occur. Attempts have been made to estimate both. All incorporate a great deal of subjective judgment, and none inspire much confidence. This is not to the discredit of the researchers. There are, in fact, great and numerous difficulties. To name only a few:

Each mineral will have its own impact characteristics;

The triggering event will set the dimension of time and degree of severity;

The state of the economy will greatly shape the impact;

It will make a difference whether more than one country is affected, both on the supplier and on the consumer side;

Size of inventory will matter, and how it is used;

Some minerals are more critical in more applications than others, or have a shorter or longer time horizon for adjustment.

The best one can say is that in situations in which potentially unstable sources are the major suppliers of a mineral used in applications where substitution raises severe technical problems or exacts heavy penalties in cost or performance, a continuous, careful analysis of potential damage is necessary. In such an analysis it is especially important to blend sophisticated modeling with intimate knowledge of technology and markets. Each by itself is likely to mislead.

Under the broad label of security of supply, there are two quite different issues, I should say at least two, that I shall now turn to. The first is a long-run issue, i.e., depletion; the second a short-run issue: supply interruptions.

Regarding *depletion* I can be brief and merely point to a chart (Table IV) that compares global reserves of eleven important metallic minerals in 1950 and 1974. The increases are striking and have occurred while material has been extracted over those same 25 years. In most instances, the additions to reserves run several 100 percent of the 1950 base. That is not ignoring the fact that the stock is fixed, that continuing use will eventually consume it, and that costs are bound to rise as higher-grade, lower-cost ore is depleted. In short, the issue is not whether stocks deplete. Of course, they do. The issue is the time horizon and the extent to which exploration and technology counteract depletion. There are successive margins in which resource exploitation is approached: the operating margin, i.e., current operations; the intensive development margin, in which known deposits are exploited more rapidly; the extensive margin, in which known but previously uneconomic deposits become workable; the exploration margin, reached through new discoveries; and the technological margin where new technology lowers costs across the board. These are useful distinctions to keep in mind when considering depletion. In any event, the day of reckoning in this area is on a far horizon, provided the role of technology, of greater efficiency, and of substitution are properly understood.

Supply vulnerability runs on a much shorter time track and constitutes the core of current concern. You will note that I use the term vulnerability, not dependence. The difference, is crucial. It is quite possible to have a heavy supply dependence—generally on imported materials—without being vulnerable. If I am well-stocked for any conceivable contingency, I can happily be 100 percent import-dependent, yet not be vulnerable. And, of course, the opposite it true. Thus, for starters, import dependence should alert but not alarm us. It was the 1973/74 OPEC experience that for a while blurred the difference. To some extent it still does. Dependence on the Middle East for a significant portion of our oil supply was seen as the real problem, whereas the real problem was in fact how that dependence, which would not vanish for a long time, could be kept from making us vulnerable. The OPEC syndrome also raised fears,

now muted, that the cartel pattern would spread to the minerals, and that mineral and other mini-OPECs would appear to plague importers everywhere. As you know, it has not happened, for a variety of reasons:

Markets were generally too slack;

Exporters could not risk even brief supply interruptions;

There was no cultural or political coherence analogous to what held OPEC together;

Substantial stocks existed, and there was room for both short-term substitution and perhaps some increase in recycling.

THE PROBLEM OF SOVIET AND AFRICAN MINERAL SUPPLIES

The cartel phobia has now given way to a more realistic consideration: the origin of U.S. materials imports, specifically imports from Southern Africa and the Soviet Union. Let me deal with each in turn, beginning with the *Soviet Union.* Here it has been suggested that the Soviet Union is pursuing a grand design, with a variety of possible objectives:

(1) To replace depleting domestic supplies with imports (thus becoming a potent competitor on world markets);

(2) To preempt U.S. access to important mineral exporters, especially in Africa; and

(3) To forge alliances with newly emerging countries, again in Africa, in an effort to dominate their economies and control their exports. Chromium, manganese, cobalt and the platinum group are the materials most often cited in these speculations.

This is a complex set of problems in a field in which I can only claim that I have studied the recent literature and find myself persuaded by those who have expert knowledge in both minerals and Soviet politics that to read a "grand design" into a variety of Soviet material imports and export moves in the last few years seems a misconception. The best I can do is to refer you to some very sober evaluations. One is by Stephen Warnecke, of Columbia University, and appeared in a June 1981 publication published in Germany, fortunately in English. I shall be glad to give the exact reference to anyone interested.[1] You will find this a careful point-by-point analysis of Soviet foreign trade moves in the mineral field. The second analysis was made more recently by Robert Legvold, of the Council on Foreign Relations as part of a broad assessment of Soviet mineral policy, funded by the Bureau of Mines and conducted by the School of Advanced International Studies of Johns Hopkins University. The entire collection is now on open file at the Bureau. Legvold—and independently William Severin in the same collection of papers—makes a convincing case that there is no systematic Soviet strategy to deny the West access to strategic minerals, or to gain assured access itself, but that it is plausible that the Soviets will grasp any opportunity to exploit political mischief-making for economic ends and exploit economic mischief-making, in league with mineral exporters, for political ends. This tells us that we must be alert to such episodes but not rush into interpreting them as long-run, well-thought-out strategies that call for costly countermeasures. What is called for is not complacency but

comprehension, including recognition that the Russians are not always 10 foot tall and that their computer models may not work any better—indeed are likely to work less well—than ours. Here is a paragraph from a Bureau of Mines summary of the papers it commissioned.

> . . . the Soviets have also found it necessary to import minerals, including bauxite and alumina, antimony, some copper, cadmium, lead and zinc, molybdenum, tin, tungsten, and nonmetallic minerals such as barite, mica, and fluorspar. It is difficult to tell in all cases whether Soviet imports signify a supply problem or are a political gesture to help some developing country rid itself of a surplus. In the case of production disruptions, which are a common occurrence, the Soviets have turned to the foreign market. In some instances they have switched from a selling to a buying posture almost overnight, and then back to selling again.[2]

The African problem, in my judgment, is more serious. For one thing, U.S. foreign policy is in a bind. Favoring South Africa will alienate the so-called "frontier states," and vice versa. Fashioning a policy agreeable alike to blacks and whites in these important mineral-exporting countries has proved frustrating. On the other hand, what we have going for us is that all Southern Africa is crucially dependent on mineral exports. Arbitrary sustained cutoffs are thus highly unlikely, and even countries, like Angola, that have come under Soviet influence, have continued to be on amicable terms with Western trade partners and companies. The real threat is not embargoes, cartels or other manipulations. The real threat is a prolonged period of internal turmoil and violence, in any one country or in several, including tribal and regional conflict. In such a climate of instability production and transportation of minerals may not be feasible, at least not on any normal scale. The world may simply lose the supplies of Southern Africa for an extended period, not because these countries *won't* produce and export but because they *can't.*

It is arguable that this is too dire a speculation. After all, both Iran and Iraq have been producing and exporting significant quantities of oil, internal and external turmoil notwithstanding. The troubles afflicting Katanga that sent the price of cobalt to $50 a pound, were, in retrospect, a brief episode. The market reasserted itself. Some users looked for and found satisfactory substitutes (e.g., in magnets), and the price, after a while, declined and now is less than one-quarter of what it was in those heady days. Perhaps, we underestimate our ability to "muddle through" and overestimate the costs. We preach belief in market forces but abandon reliance on them all too easily. At least, this is food for thought.

REMEDIES

No matter how one views the threats to U.S. mineral supply, there clearly remains a substantial risk. What then are the remedies? I have no doubt myself that strategic *stockpiling* heads the list. I assume that you are all familiar with the general features of

stockpiling, a program that is more than 40 years old. These are the salient points:

The stockpile is based on sustaining the country for a national emergency of 3 years' duration;

A National Defense Stockpile Transaction Fund receives and disburses funds, the latter through the normal budgetary appropriation process;

GSA manages the stockpile, FEMA is in charge of policy and planning;

The latest goals are as of May 1980;

As of March 1981, the stockpile was valued at $12.6 billion, of which $5.0 represent commodities in excess of goals (largely tin, silver, tungsten and diamonds). Acquisition needs were 12.5 billion or $7.5 billion net. A priority acquisition list was released in early 1981, and some purchases have been made.

What are the principal problems? I see the following:

1. The very basis, i.e., a 3-year emergency, is debatable in the age of nuclear confrontation. A big conflict, big enough to require resort to a stockpile, is unlikely to remain conventional; it would be brief. A small conflict, likely to remain non-nuclear, is unlikely to require resort to a stockpile.

2. What about release decision rules? Even in peacetime, this represents a problem, as convincingly demonstrated by the recent history of silver sales, or "non-sales." Mineral producers like stockpile purchases but detest sales. Users tend to react conversely. In an emergency, at what price do you sell to whom? How soon? At what pace? One suspects, or trusts, that somewhere there are rules; if so, they need to be fully debated. Else, industry suspicion that stockpiles are largely an instrument for raising revenues or fighting inflation will not be allayed.

3. How does holding of private stocks gear in with government stockpiling? To illustrate in the case of the strategic petroleum reserve, in the twelve months between April 1981 and April 1982, the strategic petroleum reserve grew by 120 million barrels, private stocks declined by 160 barrels, for a net loss of 40 million barrels. Should there not be a connection? Should the government try to influence and/or utilize private stocking, and if so, how? Finally, since use of the stockpile would go together with allocation, how can industry be induced not to rely on being taken care of and thus not minimize its own stockbuilding (especially at the high cost of money!)?

4. In what form should stocks be held? A recent NMAB study goes deeply into the subject. The reduction in smelting and refining capacity makes this an urgent topic.

5. If we are serious in our fear of supply interruptions and, more generally, market manipulations, is not the limitation of stockpiling to a "national emergency" too constraining; or, conversely, need we widen the meaning of the term "national emergency?" Now that we have a "strategic petroleum reserve" which is to be used precisely in a supply interruption contingency, is it not time to re-examine the purpose of the strategic materials stockpile in circumstances other than war? I recommend these questions to your deliberation.

I move from stockpiling, which is essentially a short-term security device, to *substitution,* which spans a wide range from short- to long-term, especially when you think of substitution not merely as material-for-material, but also process-for-process and function-for-function. Substitution goes on all the time, of course. It may lower costs, increase productivity, reduce maintenance needs, meet government regulations, increase security of supply, reduce exposure to price fluctuations, ease recycling or waste handling, and so on. The large number of factors cited, and it is no doubt incomplete, suggests that there are few generalities. From a public policy point of view at least three questions need to be asked:

(1) What is the timeframe we are talking about?

(2) Is there a systematic way of inducing substitution, and is there a rule for government initiative and possibly financial support?

(3) How can substitution know-how be moved from the lab to the production line, beyond the scope provided by routine business practice, and, beyond the channels now generally available?

These are issues that need to be addressed if we want to go beyond the conventional casual reference to substitution as a way of easing supply constraints. A further set of questions then suggests itself:

(1) Do firms substitute out of their own knowledge, by trial and error, or by systematic R&D?

(2) How does substitution know-how spread? Through the trade literature? Through professional organizations? Through industrial leadership? Through governmentally sponsored or performed R&D?

(3) What do we know or need to know about the impact of specific substitutions on other materials? Are there strong chain reactions?

(4) Because the R&D payoff will frequently not accrue, wholly or partially, to the performer, what is the role of government as a catalyst?

(5) Does it make sense to think of a technology stockpile or "bank" to be available in times of stress? Not a novel idea; indeed, one that, it seems to me, has been kicking around by now long enough to be given serious consideration. To be sure, the Bell Labs of this world would continue exploring and applying on their own, but now many Bell labs are there?

To summarize, substitution is an everyday occurrence; to elevate it to a remedy for supply interruptions needs a far better understanding of how it works as well as some innovative institutional thinking. Presently, its largest potential is probably in long-run adjustment to changes in supply, price, and technology conditions. Short-term substitution R&D may need a shot in the arm.

I shall deal only briefly with *recycling* as a means of coping with supply constraints, largely because I believe its importance is generally exaggerated. Those materials where recycling is institutionally easy, enjoy high recycling rates even now (e.g., lead from batteries, steel from automobiles, aluminum from containers). Organizing other flows is likely to be costly and time-consuming; but that is not a judgment, I should add quickly, based on recent, extensive research. Those closer to the scene may well assess the potential higher than I do.

When we come to *expanding domestic production,* we enter a field of sharply contrasting views, above all in the matter of *land use.* Unfortunately, as I commented in the beginning, the clash has been one of principle and the battle has been fought by citing aggregates of numbers, i.e., percent of Federal land open or closed to mining. Data in this area are very poor. So poor, in fact, that in his April 5th report to the Congress the President stated that ". . . large amounts of federal land-estimates vary from 40 percent to 68 percent—are now closed to mineral exploration and development . . ." I must say if the landlord doesn't know whether it's 40 or 68 percent or anything in between, who does? Moreover, is 40 percent too little or too much? Is 68 percent too little or too much? My answer is: I don't know, and I doubt that anyone else does. Consider also that the role of Alaskan land in these statistics looms large and will continue to do so for a while, and that the picture is further confused by interpretation of the label "slight or moderate limitation to access." Some count these areas as open (for example the Office of Technology Assessment (OTA) in its careful 1979 study), some as closed (for example, the Interior Department in its 1977 task force report, a document now hard to come by). To those interested in an exhaustive study I recommend the OTA report as still the best available.

One must applaud the intention of the government, announced in the President's report, to produce better data, but I doubt that even better data will put the argument to rest. For the issue really comes down to the quest for persuasive evidence that one can expect to come upon large occurrences of minerals, of the kind in which the country depends heavily on imports from unstable sources, precisely in those areas that are now closed to entry or accessible only under restrictive terms.

As I indicated, lack of good data merely compounds the problem by making for a largely unrewarding debate. The answer to the more important question, i.e., to what extent are closed areas more heavily mineralized than accessible ones, can come only from increasingly sophisticated survey technology, eventually supplemented by drilling. This means proceeding on a micro scale, case by case. I am not holding this out as *the* solution, but merely as a path more promising than arguing over basic values or numbers. Nor is the micro approach free of flaws. Firstly, exploration prospects are closely-held information. How a company's position could be safeguarded in this respect is a matter deserving careful attention. Secondly, environmentalists would oppose not only mining, but exploration on some categories of land; moreover, they would rightly be skeptical that anyone but government would be willing to explore unless assured that exploitation was permitted in the event of success. It may well be that, by default, a larger governmental role would be required. That, of course, would in turn not sit well with a good many people. The best one could hope for in this controversial area is that conflict would become less ideological and therefore lend itself more easily to resolution than to confrontation.

I have come to the end of a long review, which would have been much longer had I not concentrated on issues that are currently in the forefront of concern and public debate. Even within that narrowed field I have to confess to some omissions, the most glaring of

which is probably *environmental regulation.* I do not underestimate its importance as an element of both direct cost and public intrusion into private decisions. The explanation is that I do not move with sufficient knowledge in this area to speak about it confidently. As a substitute, let me cite a few passages from the above-mentioned OTA study that phrases the problem extremely well:

> The independent and preferred position historically afforded to mineral activities on Federal land has been based largely on two premises: (1) that economic concentrations of minerals, *unlike other resources,* are "where you find them," and (2) that these mineral concentrations are *always* the most valuable resource *wherever* they are found . . . neither premise is valid today.

Examining this thesis the report states:

> . . . the location of economic mineral deposits is determined by prices, markets, technology, and time in addition to geologic factors. For society as a whole, the development and production decisions for a particular mineral deposit are not simply "this deposit or none" but rather "this deposit or (eventually) a (possibly) more expensive (1) lower grade, more deeply buried, or more geographically remote mineral deposit, (2) synthetic mineral, or (3) substitute mineral.
>
> The situation for nonmineral resources is in some respects similar to the situation for mineral resources, and in some respects dissimilar. In contrast to the nonfuel minerals, which theoretically at least can be recovered and reused, some (but by no means all) nonmineral resources are subject to permanent loss. Examples include endangered plant and animal species, scenic landforms, and historical and archeological sites and objects. Others, such as wilderness, may take so long to recover, once disturbed, that their destruction is, in a practical sense, irreversible. Still other nonmineral resources recover or can be restored within a reasonable period of time at acceptable cost, analogous to the recovery and reuse of some mineral resources.
>
> Many nonmineral resources are at least as limited in physical supply as most mineral resources, and subject to the same economics of more expensive lower quality alternatives. Examples include watersheds and aquifers, potential hydroelectric powersites, old-growth hardwood timber, prime agricultural land, and white-water rivers.
>
> Thus, many nonmineral resources, like currently economic mineral deposits, are "where you find them" only in the sense that alternative sites, although physically available, are of generally lower quality and higher price. Some nonmineral resources, because of uniqueness, are, unlike mineral resources, strictly "where you find them," in the sense that alternative sites are not available at any cost. However, no generally accepted formula exists to identify uniqueness.

After commenting on shifts in relative values of mineral and nonmineral resources, the report concludes:

> When all the mutually consistent consumable and nonconsumable nonmineral resource uses, scientific and evolutionary values, ecological functions, and option preservation values of a tract of land are considered, the value of the mineral resources in the tract may be outweighed by the temporary and permanent losses in nonmineral resource uses and values that would result from developing the mineral resources, even when the social value of a secure domestic mineral supply is added to the private value of the deposit to a mineral producer. . . . The automatic assumption, in every case, of a higher value for the mineral resource can lead to inefficient resource use, even though a rich mineral resource may outweigh the nonmineral resource values in most areas. [3]

I have quoted at some length because I find these passages are excellent background for any discussion of the production/environment tradeoff, and I recommend the full version to your reading. One may elect to ignore or downgrade the way in which people have ascribed increasing value to the non-mineral resources on public lands, but only at the cost of frustrating and unproductive controversy.

Another obvious omission is that of encouraging domestic production through the provisions of the Defense Production Act. Again, I have not kept up with the debate, but let me make these brief comments. I have a feeling that the Administration's commendable devotion to free market forces is carrying it beyond the capacity of the market to deliver. It thus is bound to come into philosophical conflict with industry subsidization that is called for under DPA. In any event, we need, as a minimum, a careful and unbiased comparison of costs and benefits between subsidized domestic production, and other means of shoring up vulnerable supply positions (such as stockpiling). There is no a priori answer, valid in all situations. Pragmatism is the way to go.

As I come to the end of my alloted time, you will have rightly concluded that I have slighted many of the large continuing materials problems: the raising of investment funds, relationships with host countries, the difficulty of timing investment in new facilities to produce commodities when they are demanded, fiscal problems, intermaterial competition, trade policy, to list a few. In the long run I believe these to be the more profound issues. If I have elected to spend my time instead on those that figure most actively in the public debate, it is because they are most apt to shape policy. I hope that the choice meets your own sense of priorities. At least, by treading on highly controversial ground I can hope to have stepped on enough toes to make for a lively discussion.

In case I have failed to do so, however, let me have a final try. One of the cherished goals of the materials community is to have a *"comprehensive national materials policy."* I suggest to you that this is an elusive goal at best and a waste of time at worst. It tends to produce little more than the kinds of pious and anemic generalities in which past Congressional legislation abounds. Nor could it

be otherwise. The moment you advance from generalities, such as the call for a "sound and stable minerals industry" (whatever that might mean), you are faced with the fact that in policy terms iron ore, bauxite, titanium and copper, just to name a few, have too little in common to be blanketed by a unified national policy that goes beyond exhortations and admonitions. Focus blurs further as you reach out beyond minerals. The problems of the petrochemicals, for example, are (1) heavy excess capacity, with more coming on line in the OPEC countries and (2) uncertainty regarding relative prices of feedstocks. Wood-derived materials are at the mercy of construction activities which, in turn respond heavily to interest rate movements. As a recent NMAB study commented: ". . . it is clear that some problems are material problems only on the surface. They really stem from social and economic factors such as relative labor costs, shifts in international competitiveness, relative changes in power costs, management decisions, and regulations. Therefore the remedial options do not fall neatly into a simple category of "materials policy." [4]

My counsel then is one of moderation. In my mind that would consist of selecting a few salient issues—high among them stockpiling, substitution R&D and access to public lands—and try to make headway on them. The call for a comprehensive national materials policy you may want to inscribe on a plaque and hang on the wall over your desk; be inspired by it, but devoting your energies to trying to make it a reality seems to me time poorly spent, even though something would surely be learned in the process. There is more urgent work to be done with better odds on success. This afternoon's session should provide a fine opportunity for ventilating this issue, but I thought I'd end my presentaton with putting my oar in early and churning up the water in the process. Thank you.

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3. "Management of Fuel and Nonfuel Minerals in Federal Land. Current Status and Issues", Office of Technology Assessment, April 1979, Appendix B, p. 185ff.
4. "Assessment of Selected Materials Issues" National Materials Advisory Board, National Academy of Sciences, Washington, D.C., NMAB-381, September 1981. p. 5.

NOTE.—In preparing this paper I have drawn on material contained in a report funded by the Oak Ridge National Laboratory in May 1982 and entitled "Minerals in the Eighties: Issues and Policies, An Exploratory Essay."

TABLE I.—RAW NONFUEL MINERAL PRODUCTION, 1980, 1981

[In billions of dollars]

	1980	1981
Metals:		
Copper	2.6	2.8
Iron ore	2.4	2.9
Molybdenum	1.3	1.0
Gold	0.6	0.6
Lead	0.5	0.3
Zinc	0.3	0.3

TABLE I.—RAW NONFUEL MINERAL PRODUCTION, 1980, 1981—Continued

[In billions of dollars]

	1980	1981
All other	1.2	0.9
Total	8.9	8.8
Nonmetals:		
Cement	3.9	NA
Stone	3.3	3.1
Sand and gravel	2.3	2.3
Phosphorus rock	1.2	1.3
Sulfur	1.1	1.3
All other	4.4	NA
Total	16.2	16.7
Grand total	25.1	25.5

Source: Mineral industry surveys, U.S. Department of the Interior, Bureau of Mines, Jan. 7, 1982. All figures are preliminary.

TABLE II.—ENERGY AND NONENERGY MINERAL TRADE, 1979, 1980

[In billions of dollars]

	Gross imports		Net imports	
	1979	1980	1979	1980
Energy	60.0	83.0	54.0	75.0
Nonenergy materials	22.3	26.2	4.0	2.9

Source: For energy, Monthly Energy Review, U.S. Department of Energy. For nonenergy materials, U.S. Bureau of Mines Minerals Yearbook, 1980, Statistical Summary.

TABLE III.—U.S. IMPORT DEPENDENCE, SELECTED MINERALS

[Imports as percent of apparent consumption]

	1950	1970	1978	1979	1980
Bauxite[1]	71	80	93	93	94
Chromium	100	100	91	90	91
Cobalt	92	96	93	94	93
Copper	35	8	20	12	14
Iron ore	5	30	29	25	22
Lead	59	40	9	4	([2])
Manganese	77	94	97	98	97
Nickel	99	91	80	69	73
Platinum	91	98	90	89	87
Tungsten	80	40	56	58	54
Zinc	37	60	66	63	58

[1] 1978, 1979, 1980 includes alumina.
[2] Net export.

Note: Sources other than imports and primary production are secondary production and inventories.

Source: 1950, 1970, Report of National Commission on Material Policy, June 1973, pp. 2–23, 1978–80: Mineral Commodity Summaries 1981, Bureau of Mines, U.S. Department of the Interior.

TABLE IV.—WORLD RESERVES OF SELECTED MATERIALS, 1950, 1979

[In metric tons]

	1950	1974
Bauxite (10^9)	1.4	16.0
Chromium (10^8)	1.0	17.0

TABLE IV.—WORLD RESERVES OF SELECTED MATERIALS, 1950, 1979—Continued

[In metric tons]

	1950	1974
Copper (10^8)	1.0	3.9
Iron (10^{10})	1.9	8.8
Lead (10^7)	4.0	15.0
Manganese (10^8)	5.0	19.0
Molybdenum (10^6)	4.0	5.0
Nickel (10^7)	1.4	4.4
Tin (10^6)	6.0	10.0
Tungsten (10^6)	2.4	1.6
Zinc (10^7)	7.0	12.0

Note: Data for more recent years as published by the Bureau of Mines are no longer in terms of reserves, but "reserve basis," which is a more comprehensive concept.

Source: The Future of Nonfuel Minerals, by John E. Tilton, the Brookings Institution, Washington, D.C., 1977.

III. PANEL—KEY ISSUES ON ENGINEERING MATERIALS AND MINERALS POLICY AND HOW TO ADDRESS THEM

Introduction to Panel Presentations*

The 1970's ushered in an era of increased awareness and concern over raw materials availability and cost. Some materials shortages occurred in the early seventies due to the worldwide economic boom. In 1973–74 the Arab oil embargo caught the general public's attention by causing "gas lines" and rapid energy cost increases. OPEC became a household word. In the late seventies other less familiar commodities were in the news—cobalt shortages occurred and Zaire, its principal producer, was threatened by internal instability; tantalum prices increased nearly tenfold and its long term availability was questioned. Strategic materials, dependency, substitution and stockpile became active topics within government, industry and for the Federation of Materials Societies.

Changes have occurred since the beginning of the 1980's. A persistent worldwide recession and increased production capacities spurred by the demands and prices of the late seventies have provided ample or oversupply conditions for most materials. Some specific commodities situations could be best described as glut. Yet, concerns remain; vulnerability of industries and economies to raw material supply disruption still exist. The U.S. Government is taking a closer look at its stockpile. Japan has announced that it plans to form one. Technological spade work on substitution technology continues. Access to public lands for mineral exploration is in the headlines.

It is against this backdrop that our panel and its audience will address the issues as they are perceived today. Issues, like beauty, exist in the mind and eye of the beholder. They vary for producers, users, environmentalists, miners, the military, economists and the public at large. The challenge, as always, is to define them adequately to allow that they be faced openly and directly.

THE PANEL

John W. Goth, Executive Vice President, AMAX Inc.—presented by: David W. Delcour, AMAX Inc., Vice President and Director, External Affairs

Dr. James A. Ford, Director of Technical Engineered Products, Cabot Corporation

Julius J. Harwood, Director, Materials Sciences, Ford Motor Company

Robert D. Wilson, Director, Office of Strategic Resources, U.S. Department of Commerce

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Dr. Paul Wynblatt, Carnegie-Mellon University

SUMMARY OF ISSUES

In spite of the currently abundant supply situation, risks remain for possible future supply disruption. Materials such as chromium, cobalt, tantalum, manganese and others are vital to our national security and economic well-being. We are dependent upon foreign sources for their supply and are becoming increasingly dependent for their processing. Import dependence is not in itself the issue, as normal international commerce will continue to supply raw materials to us as well as markets for our finished products. Vulnerability to disrupted supply is the issue of concern. Vulnerability involves our ability to adapt to any potential supply disruption without serious consequences to our national security, industry, and commerce.

The vulnerability issue must be viewed in terms beyond raw material supply because it also involves the vitality of the processing and manufacturing sectors which convert these materials to the products we need.

The April 5, 1982 "National Materials and Minerals Program Plan and Report to Congress" from the Reagan Administration is welcome and viewed to be a positive declaration of intent to address our problems. But in its own language, it is but "a first step" and the full path to reduced vulnerability is long and as yet inadequately defined. Full definition will need to address several specific issues and goals.

A cornerstone of reduced vulnerability is an adequate stockpile of strategic materials which serves as a source of supply during disruption and as a deterrent to deliberate disruption by external entities. Reserve supply affords the time to resolve or implement other solutions of a longer term nature. The National Defense stockpile is currently lacking in some respects and warrants urgent attention. It must be characterized and replenished. The Stockpile management system must be changed to provide it with independence from the political and economic pressures which it has been subjected to in the past and which diminish its ability to perform its primary task in the best national interest.

Equally important is the state of our industrial capacity. A stockpile without related industrial process capability is a cart without a horse. A climate which permits the development and existence of healthy, diverse competitive industries is vital.

In the longer term, the issue of materials dependency itself needs to be addressed by determining what domestic resources are available and able to be extracted for our own use with appropriate and balanced concerns for environmental and economic factors. Public lands need to be assessed to measure which of them are potential sources for our needed materials.

There is a need to improve our preparedness for possible future supply disruptions through greater knowledge about the technologies for production, substitution and conservation. Tapping marginal deposits, improved beneficiation methods, alternate materials, manufacturing with lower input of materials, and recycling are all tools to reduce vulnerability. While

materials are available, the motivation to pursue such technologies is limited. Incentive and support for these approaches warrants consideration

Government must play its part in this basic issue. It must encourage our industrial competitiveness in the world marketplace. It has to be responsive to the needs of industry and the economy, including those beyond direct defense industries. It must address the policy issues at a level of awarenes which its importance demands. It must support specific, generic programs which will enable our industrial establishment to provide the wares that provide for our national security and economic well-being.

The above issues and challenges remain. They must be addressed; solutions must be found. This conference has an opportunity to provide guidance to this end.

Key Issues in National Materials Policy As Seen by a Raw Materials Supplier*

I've been asked to provide you with a materials producer's viewpoint of the key issues in our National Materials Policy. That is quite an assignment and one in which I can only scratch the surface during my allotted time.

The mining industry faces all of the issues which affect every business in this country. Unfortunately, the mining industry also faces a number of additional issues that are peculiar to mining.

In the time I have this morning, I would like to focus on three key issues which fall in the latter category:

—Access to public lands,

—The national stockpile issue,

—And the federal role in materials research and development.

By focusing on these three issues, I certainly do not mean to diminish the importance of the environmental, health and safety, economic and tax policy issues. All have a major bearing on the ability of the mining industry to supply the nation with an adequate, reliable flow of strategic and critical minerals.

Despite changing political and economic conditions, this nation should always be in a position to assure its citizens of an adequate supply of the food, fibre, fuels and other raw materials necessary to meet their needs.

Virtually no one in the United States will disagree with that objective. Portions of that objective have been the basis for every Materials Policy Act since the first Stockpiling Act in 1946. They are also included in President Reagan's recently enunciated National Materials and Minerals Policy.

Such a policy *is* needed. It is vitally necessary. But, reaching a concensus on *what* such a policy should specifically contain and *how* it will be instituted has made it impossible to develop meaningful, long term, workable programs to provide this country and its industries with the help needed.

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* Remarks by John W. Goth, Executive Vice President, AMAX Molybdenum Division; Delivered by David W. Delcour, Vice President, AMAX Molybdenum Division.

A problem of great concern to the mining industry and one that should also be a concern to the entire nation is our country's dependence on foreign sources for many of our critical nonfuels minerals.

A tabulation of the metals that we import is indeed formidable, and the implications of this situation are frightening. Just to hit the highlights, we rely on foreign sources for from 75 to 100 percent of our alumina, chromium, cobalt, manganese, nickel, niobium, platinum group metals, tantalum and tin. We import from 30 to 75 percent of our requirements for antimony, barium, cadmium, gold, iron, mercury, selenium, silver, titanium, tungsten, vanadium and zinc. Ten to 30 percent of our requirements for copper, lead, rare earths and silicon are imported.

Of the metals important to the iron and steel industries, only molybdenum is sufficiently plentiful in the United States to supply all of our needs.

There are three simple factors that determine America's ability to produce minerals. First, do the ore bodies exist? Second, do we know where they are? And, third, is our mining industry allowed access to those ore bodies, if they are found?

The answers are "Do they exist?" . . . "Maybe," "Do we know where they are? . . . "Sometimes," and "Is the mining industry permitted access to them?" . . . "Often not."

In the United States, our storehouse of known metals occurs between the Rocky Mountains and the Pacific Ocean and in Alaska. Since our nation was founded, the territories that now make up the western United States have proven time and time again that they are rich in mineral deposits.

The American West is also the storehouse for another treasure, our nation's public lands. Of the 2.3 billion acres of land in the United States, one-third (741 million acres) is in the public domain. Ninety-three percent of those public lands, 691 million acres, are also concentrated between the Rocky Mountains and the Pacific Ocean and in Alaska.

A 1975 study by two employees of the Department of the Interior and the Bureau of Land Management revealed that 67 percent of these public lands had been effectively excluded from mineral exploration and development because of a multitude of Congressional and Presidential decisions. No one in our government and no one in our industry was aware of the cumulative affect of these piecemeal withdrawals until this study was released.

What is even more startling is that between 1967 and 1974 just eight short years, withdrawn lands increased *fourfold* . . . from roughly 120 million acres to more than 480 million acres.

Alaska, our largest state, is a good example of the lethal effect of land withdrawals on mineral development. Situated between mineral-rich Siberia and mineral-rich northwest Canada, Alaska holds the key to some of our critical mineral needs. *Engineering and Mining Journal* has rated Alaskan prospects as excellent for tin, tungsten, chromium, nickel, cobalt and platinum. However, of 244 known major mineral occurrences in Alaska, only 46 are in areas open to mineral activity. At the current time, there are only two commercial mining operations of any size in the state. Of the more

than 586,000 square miles in Alaska, only 17 percent remain available for mineral activities.

It is totally impossible for America to achieve any semblance of minerals self-sufficiency when our warehouses of known minerals have been padlocked.

Unfortunately, only one month before releasing its minerals policy statement, the Administration proposed legislation to exacerbate the situation by immediately withdrawing all wilderness and wilderness study areas from mining activities, a total of 140 million acres. At least the 1964 Wilderness Act gives us until December 31, 1983, to explore. And, we have at least the hope that most of the 60 million acres of study area will be returned to multiple use. Passage of the Administration bill would dash those hopes for the rest of this century.

We can only mine where the minerals are found. And to find them, we have to hunt for them. That is difficult to do when America's best known areas of mineralization have been and are being declared "off limits" by the federal government. We must be allowed access to these lands to explore and obtain information about our country's ability to provide its own minerals.

Contrary to popular belief, mining does not impact large amounts of land. During the past 206 years, less than three-tenths (3/10) of one percent of the nation's 2.3 billion acres has ever been touched by mining. And one-third of that has been reclaimed.

It is only when this nation's mining industry is given access to search for areas of mineralization that we will have a sound basis to forge an effective National Materials Policy.

Let me turn now to the National Stockpile issue.

The Strategic and Critical Materials Stockpiling Act, originally enacted in 1946, provides that strategic and critical materials will be stockpiled in sufficient quantities to sustain the United States for a period of not less than three years in the event of a national emergency.

During the fifteen years following passage of the 1946 Act, metals were actively purchased to build the needed stockpiles. However, in the early 1960's, the stockpiles were determined to be excessive and, during the next 15 years, amounts in excess of the original targets were sold. In fact, several of the stockpiles were virtually eliminated between 1964 and 1975. One of my company's main products, molybdenum, was, in fact, reduced to a zero goal on the stockpile list, largely because this nation is self-sufficient in molybdenum.

Today, 60 percent of the stockpile commodities do not meet their targets. In March, the Federal Emergency Management Agency announced that the government would be spending $100 million as the first part of an acquisition program to build the stockpile from about $15 billion worth of minerals and materials to a store worth well over $18 billion.

Tungsten, on the other hand, has been found to exceed its stockpile target and is being sold from the stockpile in large quantities at a time when the market is oversupplied and prices are depressed. Not only are the sales untimely, but the awards have been below the actual market price. Needless to say, the government is losing potential revenue as a result of these sales, and domestic

producers continue either to be shut down or operating at partial capacity.

While tungsten consumers may appear to receive the benefits of this policy, some of those same stockpile tungsten consumers agree that the long term effect of the GSA's tungsten disposal practice has and will continue to jeopardize the ability of tungsten producers to provide the stable and reliable product users desire.

We endorse President Reagan's policy that the stockpile should be sufficient to meet military and essential industrial and civilian needs in support of the national defense in a crisis. We do not support the use of a government stockpile to be used as an economic control device in the market place.

It is our hope that the Administration will recognize that better stockpile management policies can only help to strengthen our domestic production and, thus, benefit not only the Treasury but the tungsten producers and consumers as well.

Of course, the best way to eliminate the market place disruptions caused by stockpile management practices is to reduce the number of commodities and the amount of each commodity required in the stockpile. Each pound of new annual production of chromium, platinum, cobalt and other critical metals, will reduce stockpile requirements by three pounds.

When President Reagan presented his minerals policy statement to Congress on April 5, 1982, he devoted a portion of that 33-page document to the need for long-term, high potential research with wide application to improve and augment domestic mineral production.

Application of the Economic Recovery Tax Act incentives could be used to stimulate private sector minerals exploration, development and production.

It would also seem that the federal government could prudently re-activate the Defense Production Act of 1950 to expand the domestic production of vital and critical natural resources as a further means of assuring independence from many uncertain foreign sources. I believe such measures could contribute significantly toward American mineral independence, but should be made available only for those materials which cannot be developed without such an incentive.

Before concluding, I want to comment briefly on the appropriate federal role in materials research and development.

Competition in the private sector is an immensely powerful mechanism for assuring the efficient use of limited natural resources. For more than 50 years the Climax Molybdenum Company has participated in this process, identifying new and more economical uses of alloy elements and assisting users and producers in bringing these new products to full and economical implementation.

But therein lies both the strength and limitation of the private sector in dealing with strategic material concerns. It is the expectation of immediate commercial utilization that drives this powerful mechanism.

So in defining the strength of the private sector, we define the proper role for the Federal Government. The Government should perform, or provide the incentive for, research and development on

materials substitutes that are not presently justified economically, but which might be justified in the future.

The goal is a state of knowledge that makes substitution for critical materials possible.

It is essential that any federal program, whether related to resource development, strategic stockpiling, or technological development, meet one criterion:

> that is does not distort, stifle, or interfere with the competitive, economically justified research and development of the private sector responsible for our national industrial strength.

Again, summing up what I perceive to be three key issues for a National Materials Policy as seen from a minerals industry viewpoint:

—Such policy should address the issue of access to public lands for mineral exploration and development in the western United States including Alaska. The policy should contain specific provisions which assure that access will be available for as long as is needed to document and inventory the mineral reserves of this nation.

—With regard to the national stockpile of strategic and critical materials, it is imperative that sufficient quantities of mineral resources be stockpiled to sustain the nation and its people during times of national emergency. However, these stockpiles should be given careful stewardship and their use should not cause economic disruption or inflict hardships on the domestic industry, . . . such as the on-going disposal of stockpile tungsten.

—The federal role in materials research and development is to act where there is no economic incentive for the private sector. Knowledge that makes substitution for critical materials possible also makes the need for actual implementation of such noneconomical substitution unlikely. Knowledge of substitutes removes the potential for political interference through disruption of critical materials supply. A strong commitment for fundamental materials research aids in development of substitutes while building the foundation for national technological development.

Key Issues on Engineering Materials and Minerals Policy: An Industrial User's Viewpoint*

There are many key issues that can be addressed when discussing the subject of National Policy in relation to engineering materials and minerals, and I will look in some detail at two of these issues. But first I think it is appropriate to briefly explore the broad role of the Federal Government in a National Policy.

ROLE OF FEDERAL GOVERNMENT

First, an effective National Policy must provide for a stable geopolitical climate within the minerals-producing community so as to

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insure that economic manipulation cannot occur. There must be mutually beneficial political understandings between the United States and those countries upon which we rely such as South Africa, Zimbabwe, Zaire, Zambia, Australia, Brazil, Canada, etc. These understandings must promote the existence of a free marketplace within which competitive forces can effectively work. It is recognized that this is a "tall order" which is made all the more complicated by the fact that the list of countries with which we must deal represents a range of political viewpoints, stability, and large variability in the degree of industrial and economic development. Accordingly, we must approach each critical or strategic mineral/country combination as an entity unto itself.

Second, the National Policy *must* provide for the continued availability of materials in the case of a National Emergency. The provision of a useful stockpile is without question foremost in importance. I will discuss specific issues in this regard later in the talk.

Third, the Federal Government should provide an environment within which meaningful R&D can be conducted. *Meaningful* will have differing meanings to different people. My interpretation is:

1. R&D directed toward improving the economics of onshore mineral recovery and utilization, e.g., Co, Cr, Mn, etc.
2. R&D directed toward substitution of noncritical elements for more critical or strategic elements such as Al and/or Si for Cr.
3. R&D to encourage recycling of obsolete scrap. We must make full use of the Cr, Co, Ta, Be, etc. units which we import into our materials stream. This is difficult when these units can and do become contaminated as they leave the secondary fabricator's control. In addition, and perhaps somewhat parenthetically, the fact that large quantities of Cr leave our materials system as scrap sold offshore is indeed of concern and in my opinion requires rectification.

Last, the Federal Government must provide a climate within the United States in which our materials-producing community can procure, produce, and market products competitively worldwide. I do not mean that we must have a completely open door for miners, smelters, secondary fabricators, OEM's, etc. that would allow them to infringe on the rights of the rest of our society. There must be a responsible balance between the needs of our productive capacity for low cost and the need to provide safe and clean environments for all of us to enjoy.

SOME SPECIFIC RECOMMENDATIONS

Commenting on the Federal Government's broad role in a National Materials Policy is far easier to do than is giving specific recommendations. What's more, there is an infinite subset of issues encompassed within the four broad points which I have discussed. In order to provide some stimulus to the discussions that are to follow this week, I would like to deal with the questions of the U.S. defense stockpile and, if time permits, substitution in more detail.

As I have previously mentioned, the stockpile first and foremost should be used for national emergency situations. On the surface that says wartime use and I certainly support that first tier limita-

tion. However, I believe we may need to consider a broader definition of national emergency. What happens if the governmental efforts are not successful in providing stability of political and/or economic relationships so that a non-fuel minerals parallel to the Arab nation oil situation of 1973–74 occurs? The first and most obvious answer is that prices will escalate out of control and cause great economic discomfort such as occurred with Co in 1979–80. Should we use the stockpile in such a situation? I think not. However, carry that situation to the extreme of a group withholding the total supply of a critical or strategic element from the marketplace (an embargo) for an extended period of time. What then? I would suggest that use of the stockpile should be considered then. Let me make myself absolutely clear. I am steadfastly against using the stockpile as an economic club to manipulate the marketplace. On the other hand, we must be able to use it if a particular resource is denied to us through actions just short of war, such as an embargo. I believe that providing continuity of supply through stockpile use in such a situation will allow normal economic forces to be brought to bear within a period short enough that the embargo will be broken. This is certainly true for the developing nations, and such a situation is unlikely to occur with the industrially developed countries.

The present stockpile has been roundly criticized as being out of date, useless (Co), etc. Recent publicity has even put in question the 5.2 MM pound Co acquisition of last year. (The material met specification in Zaire but was oxidized when it arrived.) I believe that the current organization for the management of the stockpile is less than could be provided and hence will lead to continued criticism and concern. The stockpile is a raw material (and, as you will see as I proceed, work-in-process) inventory and accordingly it must be managed as such.

Material must be purchased to realistic specifications which represent the total range of applications. For example, it has been stated that none of the cobalt in the stockpile (before the recent 5.2 MM pound purchase) was useful. This might be true from the standpoint of the aircraft turbine rotating part manufacturer, but it certainly is not true from the viewpoint of an M6 tool steel manufacturer. The point is that there are a range of specifications that must be satisfied and the stockpile management must know and provide for such a range.

Once purchased, the material must be maintained in a useful state, its whereabouts must be known, it must be readily available. I am led to believe that the present situation does not reflect such knowledge. We don't know the quality of our cobalt stockpile and hence the location of good and bad material.

The form of materials in the stockpile must be managed. What does that mean? As I indicated, the stockpile is an inventory, specifically a raw material and work-in-process inventory. However, in many cases the present stockpile does not represent all forms of an inventory. Indeed in the case of an emergency where supplies were interrupted, we could well find our productive capacity also interrupted. For example, the Cr stockpile is largely in the form of chromite (chromium ore). In the light of the declining ability of our domestic ferrochrome industry to compete with offshore capacity, es-

pecially that in So. Africa, it behooves us to provide for ferrochrome (and more highly refined forms of Cr) in the stockpile—or alternatively provide assistance to the U.S. ferrochome industry to maintain its viability. A decision between these alternatives can be based on a sound economic analysis. Each critical and strategic element in the stockpile should be analyzed in this way and an appropriate stockpile mix of ore, semi, and finished elements maintained.

There exist serious questions about the chemistry and hence the usability of many of the stockpile materials; I have already mentioned cobalt, beryllium can be added to the list as well as others I'm sure. Accordingly, a serious physical and chemical audit of the pile should be made; in fact, to my knowledge industry has offered its help. Let's get on with the job.

It is clear that all of the above examples represent materials management factors that each industrial metal producer, fabricator, and user must control in order to remain a viable on-going business. Accordingly, I suggest that an effective stockpile management team should have industrial representatives on it. Consideration must be given to developing such a stockpile management team.

As a last point in my stockpile discussion, I would like to present to this group a suggestion that will lead to more effective management and at the same time probably reduce the expense of the stockpile. Cabot Corporation recently suggested through testimomy given by William D. Manly to the Senate Subcommittee on Science, Technology and Space[1] that serious consideration be given to cooperative government-private stockpiling. The gist of the idea is to provide assistance to industry to hold minimum stocks of critical materials which in the event of a national emergency will be available to meet the nation's requirements. The assistance could be in the form of tax relief (subsidies) or some form of use of Title III of the Defense Production Act. Such a privately-held inventory can impact many of the points I have raised above concerning stockpile management. For example, because the holding industry is using and is intimately familiar with the material, it is highly likely that specifications, form, quality, etc. will be optimized at any given time. Furthermore, the inventory will be turned and hence its costs as well as its suitability will be optimized. And, lastly, the whereabouts, records and analysis of the material will be accurately maintained.

Private stockpiling is not a new idea; it has been succesfully implemented in Switzerland and is being considered by other governments including France, West Germany, Japan, Great Britain, and Sweden. Accordingly, it would seem that we might benefit by a serious look at a public/private partnership as an option to meet our defense stockpile needs.

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[1] Hearing on National Materials and Minerals Policy Act of 1980—Subcommittee on Science, Technology and Space of the Senate Committee on Commerce, Science and Transportation, Washington, D.C., June 23, 1982.

SUBSTITUTION AND/OR CONSERVATION

Up to now I have been concerned with some specific comments about optimizing our ability to avoid disruptions of supply in the event of emergency. Let me now turn my attention to the question of reducing our dependence on the more critical of the minerals which we must import.

A lasting impact can only be made if we can reduce or eliminate our need to use the mineral in question. The only way I know of doing this is through the "innovation" process. I have avoided the use of the term R&D since it tends to have a more limited connotation than I intend. The innovation process includes the total cycle beginning with the original idea or invention and proceeding through the research, development, manufacturing, and marketing stages. Oftentimes the last step, marketing, is the most difficult and even most time-consuming. For metal and alloy semifabricators such as ourselves, the new alloy (product) must be taken to OEM's and "designed" into their product; at best a time-consuming situation. There must be an economic incentive for the OEM even to consider this "design" effort.

Now, let us look at a specific substitution (conservation) situation in the context of this "innovation" process. Chromium is in my opinion the most critical and/or strategic element in our economy. (Some might argue that Mn should hold the top spot due to its role in sulfide control in steels. I would put it second since there are known substitutes: rare earth additions and vacuum melting, albeit very expensive.) There is no known substitute for Cr where it is used as an alloying element to promote surface passivity, e.g., in aqueous environments where corrosion is the main concern. Accordingly, unless there is some real breakthrough of an inventive nature, we will have to continue to depend on Cr for these uses. In addition, more than a little Cr is used as an alloying element to promote oxidation resistance, starting with simple 12 Cr stainless steels and going on up the alloy scale to the most highly alloyed Ni and Co base alloys. In this case, there is a high probability that combinations of Al and Si, perhaps in combination with small amounts of Cr in Fe and Ni bases, can provide improved oxidation resistance to the stainless steels (See U.S. Patents 3,730,779, 3,810,754, and 3,811,874) and perhaps even to the more highly alloyed Ni and Co alloys.

The problem here lies not in the probability of *inventing* an alloy combination that could substitute for high Cr-containing alloys in oxidative environments but in having the incentive to carry out the complete innovation cycle in an industrial (private) setting. Chromium is just too cheap as an alloying element in stainless steels to allow for an economic incentive to undertake the cost of and provide a return on an innovation project directed toward providing a substitute for it. It is my contention that the same pertains to many of our critical and/or strategic minerals. Accordingly, a National Materials Policy, if it is to provide more than safety from emergency disruptions, must be supportive of the innovative process directed toward substitution. I must confess that I cannot do more than suggest support. The question is complex and has been studied in detail over the last decade without providing many

good ideas. Perhaps, I can conclude this by asking, should the Federal Government try to force the process against market considerations, or should substitution be driven only by market considerations?

CONCLUDING REMARKS

I have tried to provide some points for consideration throughout our deliberations this week. As a user of critical and/or strategic minerals I believe it is key to our security that a continuous supply of these minerals be available. The keystone of a National Policy should be to provide the geopolitical climate within which such a secure supply can be maintained. More specifically, I have suggested:

1. Provide a joint industry/government stockpile management team.
2. Consider a public-private stockpile system where the industrial user maintains a minimum inventory of material in the optimum form for that industry.
3. Should the Federal role be to force or support substitution even though there is no economic incentive?

SOME INDUSTRIAL VIEWPOINTS ON NATIONAL MATERIALS POLICY *

During the past decade there has been a continuing ferment about the need for establishing a National Materials Policy in the United States. Numerous Congressional hearings and legislative offerings, government sponsored commissions and studies, professional society panels and conferences, and countless speeches and debates focussed on the growing dependence of the United States on foreign overseas sources of supply of critical and strategic minerals. Concerns about concentration of minerals reserves in particular countries and geographic areas—particularly Central and Southern Africa—and the possibility of geopolitical instabilities interfering with mineral accessibility were recurrent themes. Related topics were problems affecting our domestic minerals and basic materials industries, the use of Federal lands for mineral exploitation, stockpiling, environmental regulation legislation and other domestic issues.

Dependence (on foreign sources) was equated with vulnerability. A National Materials (Minerals) Policy was seen by many as an essential instrumentality to protect the United States from such vulnerability and potential threats to national security and the industrial economy. The need to avoid sudden disruptions to supply, that would make it impossible to produce essential equipment for our military/industrial complex, underlie the focus on a National Materials Policy to provide the mechanisms and capability for contingency planning. Potential contingency issues and "what if" scenarios involve:

(a) The "next oil" theory—minerals cartelization and/or embargo modelled after OPEC.

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* By J. J. Harwood, Engineering & Research Staff, Ford Motor Co.; and R. W. Layman, Corporate Strategy and Analysis Staff, Ford Motor Co.

(b) Geopolitical destabilization and price and supply destabilization.

(c) "The Resource War"—conjectured long term strategy of USSR in Africa and Asia to control strategic minerals sources or promote super cartels.

(d) The New International Economic Order of the Third World, which was set forth as a major threat to U.S. security.

In general, in this country, we have tended to think of ourselves as resource suppliers rather than consumers and the growing perspective of our dependence upon foreign-sourced strategic minerals and materials has made us uncomfortable. Needless to say, we are not unique in this reliance upon foreign sources and indeed are much better off than Western Europe and Japan which have almost a complete mineral dependence upon foreign imports. But in contrast to those countries, there is the strong sense that our concern about strategic minerals is approached basically as a military preparedness issue, not an industrial one.

Much of the discussion is centered around such materials as cobalt (particularly), chromium, platinum, titanium—all of which are critical to defense and aerospace products and systems. With the exception of manganese, other materials (which while not strategic in the sense of national security, are critical to the maintenance of a strong industrial base and to the production of consumers goods) were, at best, considered as secondary issues. Relationships between the health of our basic materials industries (steel, aluminum, copper) and our national economy and industrial competitiveness were virtually ignored.

Some resolution of this national debate seemed to result with the enactment of the National Materials and Minerals Policy, Research and Development Act of 1980. In April of this year, the President submitted to Congress a report of actions taken to implement the Act dealing notably with the issues of Federal land availability, stockpiling, minerals data collection, and materials R&D. Perhaps of major significance is the role of the Cabinet Council on Natural Resources and Environment in coordinating materials policy issues on a high level of governmental visibility. But despite these recent actions, the issues still appear to occupy a Washington focus. Congressional hearings on critical materials problems and national materials policy still are taking place. This Conference is but one of several this year dealing with this topic.

One of the more perplexing features is the crisis-like atmosphere which surrounds this picture, notwithstanding over ten years of deliberations and discussions and the current general relaxation of the minerals situation (particularly cobalt and titanium). It is likewise puzzling to an outsider (i.e. the non-defense, non-aerospace industrial community) to view the decade of debate about a National Materials Policy and wonder as to what inhibits the ready establishment of needed policy and implementing actions. The tools for contingency planning and legislative authority reside in the administration—recently confirmed by the April White House report to Congress. A recent study by the National Materials Advisory Board (conducted for the General Accounting Office) revealed that it was not policy formulation that was at stake—the policy process was working well. The issue appeared to be lack of implementation

follow-up—the commitment, responsibility and certainty to achieve policy objectives.

We seem to be engaged in our own "Resource War" syndrome between Congress and the Administration, between Federal land use proponents and anti-land use advocates, between those in favor and those opposed to economic stockpiling. Perhaps of more consequence is the deeper concern that the muddled nature of the situation is but another manifestation of the technological uncertainty which has permeated the American innovation and investment climate.

INDUSTRIAL PLANNING FOR CHANGING MATERIALS UTILIZATION PATTERNS

It seems appropriate to comment about a decision planning framework for materials supply from the perspective of an industrial user of materials for consumer products—particularly that of a large consumer-oriented, mass-production automotive company. It is our belief that the new forces and pressures stimulating changing materials utilization patterns may reflect a more general industrial situation than that which holds only for the automotive industry. It seems self-evident that the critical decision points in industrial (consumer) planning for materials availability and usage will be influenced by any National Materials Policy and in turn will influence and be an intrinsic part of such a policy. We have to realistically recognize that the individual and aggregated actions and internal policies of the industrial sector constitute an essential part of the national materials policy picture.

Starting with the "materials crisis" of 1974, when perhaps for one of those unusual times, in the absence of a war or national emergency, American industry (particularly that sector involved in the manufacture of civilian goods) was confronted with an ongoing set of critical shortages of materials which not only affected profitability and productivity, but in some instances threatened the very operation of industrial concerns. That troublesome period led many industrial organizations to undertake individual analyses of "materials crisis" (concerns about supply, availability, price trends) and introduce organizational components to maintain a materials strategy perspective (contingency planning). The concept of "materials management" became recognized in industrial organizations and took on new dimensions. The management of materials may be described as encompassing all technical and business decisions which control and direct the flow of materials at all parts in the use cycle from materials production and supply, through product design and fabrication, to use and disposal (or recycling). The principal planning objective should bc to improve the responsiveness of the consuming sector to potential change in supply and price.

Such materials issues as outlined below are under continous assessment as part of materials strategy—particularly with reference to changing utilization patterns:

(1) Economic and availability trends for major automotive production materials and the general conditions which might be expected to affect the availability and supply of materials for the remainder of the 20th century.

(2) Identification of critical problem areas in materials in future requirements.

(3) Elements of a design and supply strategy to minimize future materials availability risks and contingency plans to adapt to changing supply situations.

(4) Influence of materials costs on future utilization patterns.

(5) Research and development needs for new or substitute materials and the potential of enhancing materials availability through recycling and solid waste disposal of scrap materials.

(6) Industrial facilities and capacity needs with respect to future requirements and demand/supply balance.

(7) Development of new manufacturing methods to minimize wastage of materials.

FORD INTERESTS IN NATIONAL MATERIALS POLICY

A number of specific features of this materials strategy underline Ford's continuing interest in national materials policy formulation:

(1) *Ford as a Major Industrial User of Materials*—Materials are the "guts" of the car and the automotive industry and it is only natural that my Company would have an ongoing interest in national materials policy developments. We are a major user of materials on the national scene (see Table I). Obviously any policy program that affects U.S. Materials supply and use could affect automotive usage and in turn changing automotive requirements could impact the role of materials policy.

(2) *Changing Trends in Materials Usage*—We are witnessing a materials revolution in the automotive industry with a remarkable openness to exploring, evaluating and using all materials opportunities to achieve future vehicle goals. New high strength steels, fiber reinforced composites and structural plastics, and high technology ceramics represent some of the new automotive materials. By the mid-1980's, the average vehicle will weigh under 3,000 lbs. While still comprised of 50 percent steel, some 150 lbs. of aluminum, 350–400 lbs. of new grades of high strength steels and some 250 lbs. of plastics per car will be used. As compared to the late 1970's, the use of grey cast iron will be decreased by about 40–50 percent. This changing mix not only impacts basic material industries, but also influences materials flow through the life cycle and recycling processes.

We are vitally interested in the future status of our basic materials industries, such as aluminum and steel, which do not fall under the general category of critical materials. Yet it is not likely that another major aluminum refining plant ever will be located in the United States and perhaps no new modern steel plant will again be constructed within the United States.

It seems probable, despite downsizing and lightweight materials substitution, that for the rest of this decade the average U.S. car will still consist of 50–60 percent steel (albeit a smaller and lighter car with less absolute steel poundage). Some 30 percent of this steel use will involve the new high strength steels. The financial and technological ability of our domestic steel industry to modernize

and install new capital facilities to supply these advanced grades is of critical importance to us.

We have here a case of a consumer oriented materials using and fabricating industry driving a basic materials producing industry (steel) to produce and supply new classes of steels to substitute for its already entrenched products. It illustrates the interesting problem of opening up new materials markets—which do not provide for the overall growth and expansion for the steel industry—but at best can only enable a reasonable retention of current market position. On the other hand the steel industry is well aware that inadequate response to these new driving forces may weaken their competitive position vis a vis plastics and aluminum which are aggressively moving into this dynamically changing field.

A basic question which seems to require governmental clarification is whether a strong, domestic steel industry is essential to our national security and economic well-being. If the answer to that issue is positive, then national policies and actions are needed to provide the steel industry with the tools, capital and incentives to modernize for the future. Continuous annealing lines, bake-hardenable steels, dual phase steels, high quality-high formability steels, improved galvanized steels are some of the newer steel technologies which the U.S. steel industry must build up to supply our needs and to compete with the existing Japanese competitive advantages in this field. If the current steel industry difficulties prevail—the domestic share of U.S. produced steel use may decline substantially. This situation poses significant long-range problems for the automotive industry.

Future plans of the U.S. aluminum industry seem to focus on the offshore siting of new alumina refining and smelting plants where bauxite resources exist and where energy costs are favorable, e.g. Australia. Some 93 percent of our bauxite requirements now come from abroad, mainly Jamaica and Australia. These new plants may still be "owned" by U.S. producers and may make economic sense from an individual company viewpoint. The real issue here, however, is whether this makes the United States more vulnerable to interdiction of supply routes and possible future political changes in these countries. Does it make any fundamental difference to the United States as to whether we import bauxite vs. alumina, or even primary aluminum ingots?

As the emerging thrust of the New Economic Order of the Third World becomes more aggressively implemented, we will face not only questions of raw material accessibility but new foreign competition in primary metal production as well. One may speculate that the issue of strong foreign government (subsidized or controlled) competition may become a stronger driving force for effective U.S. government action on materials policy than some of the issues now under consideration.

(3) *Automotive Use of Critical Materials*—In the mid-1970's, the U.S. Army War College Strategic Studies Group rated Cr, Pt, W, Mn, Al, Ti, Co as most critical for the U.S. with a high vulnerability index. Interestingly enough, in recent years W, Co, Pt, Cr and even Ti have become of special "strategic" interest to the automotive industry:

(a) Platinum group metals (PGM) are essential ingredients of catalytic converters in widespread use for emissions control. Automotive industry requirements now constitute some 50% of domestic use of platinum. The PGM's perhaps constitute our only serious concern with automotive use of critical materials and we have taken several action steps to mitigate against future contingencies. Long term supply contracts and company stockpiling are expected to prevent any short term market perturbations from affecting vehicle production. For the longer term, the use of non-platinum base metal oxides appears to be a promising development.

(b) 12% Cr steels are extensively used for catalytic converter containers and associated piping. In fact the automotive industry uses 50% of the overall U.S. production of these stainless grades. No effective materials substitution or reliable coating systems seem to be in the near term picture.

(c) W and Co are the main ingredients of cobalt bonded tungsten carbide tool bits which have been a mainstay of machining operations. While not a predominant component of the U.S. cobalt use picture, we are decreasing significantly automotive usage through the substitution of new advanced ceramic grades of cutting tools and through the use of coated tool bits to increase productivity and tool life.

(d) Recent interest in special applications of Ti for weight reduction in advanced engines.

(4) *Materials Policy—Industrial Policy Relationships*—Materials are tools for the industrial consumer products industry. But so are labor, capital and other factors. This leads to the conjecture of whether we can establish a truly effective materials policy independent of national broad-based industrial and economic policies. Aside from the question of overseas supply dependence, the important issues besetting the materials field are often not unique to the field of materials and often not technological in nature. A materials policy, independent of its role as only one feature of a more comprehensive industrial policy could prove to be a sterile exercise. A new coupling of industrial and foreign policy relationships to deal with projected aggressive modes and systems of foreign competition might be a more vital issue for our national action agenda than materials policy, per se.

(5) *Supply Assurance*—The biggest technical challenge faced by the automotive industry in its post World War II history is the need to meet the fuel economy, emissions control, foreign competition, productivity and manufacturing cost pressures as well as other challenges in the market place all at the same time. It is demanding a most concentrated commitment of finances, new production facilities, tooling and engineering effort and human resources—perhaps more demanding than ever made by any peacetime industrial change.

Assurance of a steady supply flow of new materials is a critical factor underlying the success of this massive investment. Development of materials management planning strategies and techniques to cope with market oriented cost factors, unpredictable "what ifs," and the new uncertainties of the future constitute an industrial microscale representation of a national materials policy.

DEGREE OF MATERIALS CRITICALITY-VULNERABILITY INDEX

It seems reasonable to extend the concept of strategic minerals from its traditional role of being vital to national defense and military security to a broader perspective; that is, to those resources (minerals/materials) vital for their contributions to national well-being—not uniquely for national defense—but for industrial and economic strength. Their interruptions or cessation of supply (for whatever reasons) would have grave effects to industrial (civilian) production and productivity.

From an industrial or individual company viewpoint, the "degree of criticality" would be gauged in terms of the company's product with respect to the performance of required functions and market goals. This view of "criticality" of materials could involve a different set of driving forces and policy formulations as functionality, product design, product performance and cost assume more important roles than foreign source dependency.

The "degree of vulnerability" is assessed by examination of "what if" scenarios and the development of options or trade-offs for contingency planning. In essence, the "degree of vulnerability" of a materials class reflects the necessity for planning with or for uncertainty. In his book "How to Avoid Strategic Materials Shortages," B. O. Szuprowicz discusses the concepts of a vulnerability index to indicate the vulnerability to supply disruption. It involves a weighting of the critical danger points inherent in the materials being used and the events and conditions conducive to future crises.

In addition to a *national vulnerability index,* he proposes the use of, (1) an *industrial materials vulnerability* index involving materials of special significance to a particular industry; (2) *a corporate vulnerability index* to provide basic inputs for manufacture of company products—this is similar to the concept of materials management previously discussed; and (3) a product materials vulnerability index. These indices would be basic inputs to a company's overall product manufacturing strategy. Obviously, on any level, to develop such measures of risk factors, we must have an effective information system for alerting management in advance of problems of critical materials availability and the capability to examine the elements of risk and price and supply disruption.

Analysis of current and future automotive materials needs provides examples for the application of these concepts for examination of issues of degree of criticality or index of vulnerability:

Objective	Materials Criticality/Vulnerability
(1) Improved Fuel Economy/Vehicle Weight Reduction	Assured stability of price and availability of high strength steels, composites, aluminum.
(2) Achievement of Regulated Emission Standards	Accessibility to foreign supply sources for PGM's and Cr.
(3) Advanced Power Plant Systems	Development and supply of high technology ceramics and composites.

SUBSTITUTION PREPAREDNESS

R. A. Adams of Chase Econometrics in a recent talk before the Conference Board cogently pointed out that the key variable under the control of the industrialized countries in the strategic metals equation is not really the supply variable, *but the demand variable.* One major capability at hand to adjust the demand variable is of course the reduction of consumption of "critical" materials through materials substitution.

Some of the types of materials substitutions projected for current and future vehicles were noted earlier. It cannot be over emphasized that, in the absence of a crisis, substitutions are functionally and economically driven; trade-offs between performance and cost are engineering facts of life.

This is particularly true in the automotive industry. One of the major trade-offs in competitive materials utilization patterns involves quantification of cost-value functions. The concept of cost/lb. of weight is now being emphasized as a modulated cost factor in assessing materials application trade-offs. It is primary factor in our current reluctance to use sheet aluminum alloys extensively in body applications. Although they enable significant weight savings, the weight reduction opportunities are not yet high enough to justify the high cost penalty associated with their use. While these new cost factors may be uniquely applicable to the automotive industry, other product industries could generate their own related cost/unit value functions for a changing materials world.

While it is easy in principle to endorse the "substitution preparedness" program and initiatives being espoused by Allen Gray of The American Society for Metals, reliance upon the leadership of the Federal Government to develop enhanced substitution and conservation incentives and programs simply is not adequate to get the job done. It requires at the very least strong cooperation between the government and industry and also the active participation of our technical societies. The successful development of the National Emergency steels during World War II exists as a classic example of cooperative industrial/society efforts for materials substitution and conservation of alloying elements.

The constraints of the technological features of applications; the time and engineering work required to validate substitutions not only from a manufacturing point of view but from product durability and reliability considerations; the need to optimize cost, design and functional features; and the need to develop specifications—all of these make it imperative that industrial R&D take a lead role in the vital and necessary program of substitution preparedness. Decrease of dependence on critical materials through substitution should be a driving force for future industrial and government supported materials R&D.

CONCLUSIONS

Perhaps it is fitting to close with a plea for a common sense, rational approach to deal with the nation's materials problems (real or conjectured) based upon the lessons of past experience. To quote from a recent NMAB report, "Assessment of Selected Materials Issues:"

"Experience emphasizes the need for rational, continuing analysis of the nation's position in materials supply and for the consequent ability to foresee problems and devise responses. Such analysis certainly can lead to concern in specific instances, but should not lead to panic. As noted at the outset, this country is relatively well off in materials. If a distant nation is viewed simplistically as having a stranglehold on our supply of a particular metal, it is all too easy to call for immediate governmental action. If the domestic production base for an important metal is in decline, we need not leap to the conclusion that such decline is uniformly bad and act at once to forestall it. Experience, and the findings of the assessment reported here, belie a need for dramatic crisis action in these and similar situations. The nation's problems in materials supply are tractable. But well designed strategies and continuing analysis, commodity by commodity, are essential to keeping them tractable."

This is the essence of a workable national materials strategy.

Our favorite guru in this arena is Hans Landsberg of Resources For The Future, who persuasively argues that dependency need not be equated to vulnerability. In fact, dependency likely will be an essential part of international relationships in our rapidly changing world. Minerals/materials policy clearly is enmeshed with national security, international trade, foreign policy and domestic, economic and industrial policies. Perhaps the changing nature of foreign competition coupled with concerns about U.S. innovative and productive capabilities will stimulate a more broad-based view of national industrial policies to ensure the health and competitiveness of the U.S. industrial sector for both minerals/materials producing and using industries.

One final thought: policy seems most implementable and durable when it has an appearance of "goodness" as a characteristic. This seems to promote the desired supporting consensus. In this respect, the changing character of the minerals resources world challenges us to recognize their legitimate aspirations and developmental problems and to maintain a course of fair dealings and equity, while we try to protect our national security. We consequently have the opportunity and challenge to promote materials policies that have a teleology—a purpose of moral commitment as well as a safeguard for national security and industrial growth.

TABLE I.—*Automotive materials requirements as percent of national consumption*

Iron and steel	~ 20
Aluminum	~ 15
Copper	~ 12
Lead (15 percent in gasoline)	~ 70
Zinc	~ 35
Platinum group metals	~ 40

GOVERNMENT VIEWPOINT ON ENGINEERING MATERIALS AND MINERALS POLICY*

[Not submitted for publication.]

*By Robert D. Wilson, Director, Office of Strategic Resources, U.S. Department of Commerce.

Addressing Problems of Materials and Minerals Policy: An Academic View*

Those who have preceded me here today have provided a comprehensive description of the key issues of materials and minerals policy and I would like to devote my talk to an academic view of how to address those issues. There are basically two avenues for addressing problems related to materials and minerals policy in academia: they are the traditional academic functions of education and research. Of these functions, only that of education is an exclusively academic activity. The other one is engaged in by professionals in industry, government and consulting firms. Therefore, my talk here today will focus primarily on education, although I will say a few words about the differences between academic and other forms of research towards the end of this talk.

I would like to begin with a brief discussion of education in the broader context of what we might call "technology policy," before proceeding with the more specific area of interest to this conference, namely materials or minerals policy. My remarks on this subject are drawn in part from a lecture on the subject of "Engineering School Graduate Programs in Technology and Public Policy" delivered by my colleague Granger Morgan a few years ago at this conference (Henniker, N.H., July 11, 1978).

In contrast with "public policy" or "public administration" types of academic programs, which proliferated rapidly during the 1960's, technology policy programs at academic institutions are still relatively few and far between. Some examples, out of perhaps a score of such programs, are the Department of Engineering and Public Policy at Carnegie-Mellon University (C–MU), the Technology and Policy Program at the Massachusetts Institute of Technology (MIT), the Department of Engineering Economics Systems at Stanford University and the Department of Technology and Human Affairs at Washington University in Saint Louis. Carnegie-Mellon and Washington Universities offer full undergraduate and graduate programs, whereas Stanford's program is basically a graduate level activity. The activity at MIT is a program rather than an academic department and offers a master's degree. The "program" approach is the most common mode of technology policy activity at universities and generally consists of loosely affiliated faculty based in traditional departments who have individual interests in issues relating to the technology-society interface.

The educational philosophy behind technology policy activities ranges over a spectrum which is strongly rooted in policy analysis at one end, and predominantly based on traditional engineering at the other. There is clearly no "right way" to organize these programs and the differences between them have arisen mainly from differences in the institutional settings as well as the backgrounds and leanings of the prime movers behind these activities.

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*By Paul Wynblatt, Departments of Metallurgical Engineering and Materials Science and Engineering and Public Policy, Carnegie-Mellon University.

AN EXAMPLE—C–MU'S DEPARTMENT OF ENGINEERING AND PUBLIC POLICY

Since I am most familiar with the way things are done at C–MU, I would like to amplify a little on the educational activities in technology policy departments by using the Department of Engineering and Public Policy (EPP) as an example. Whenever possible, I will draw my examples from materials related activities.

The EPP faculty is made up mostly of engineers whose appointments are split on a 50/50 basis between EPP and one of the five traditional engineering departments. For example, in my own case, I hold a joint appointment in the Departments of Metallurgical Engineering and Materials Science (MEMS) and of Engineering and Public Policy. This arrangement is a deliberative part of the Department's philosophy and serves a number of purposes. The fact that about half of the faculty's activities follow the traditional quantitative approach to teaching and research makes it more likely that the faculty will apply similar quantitative methodologies to its technology policy activities. This arrangement also ensures that all of the traditional engineering disciplines are represented in the department by persons who are in touch with forefront research in their respective fields, and tends to foster the establishment of collaborative activities between EPP faculty and faculty in other departments. There are also two members of the faculty who hold full time appointments in EPP and various loosely affiliated faculty from departments in the School of Humanities and Social Sciences as well as the School of Urban and Public Affairs.

THE UNDERGRADUATE PROGRAM

I would like to turn now to the undergraduate program in EPP to give you some idea of the training that is being provided to a budding generation of technology policy analysts. The undergraduate program was established in 1970 within the Carnegie Institute of Technology which is C–MU's School of Engineering. The establisment of this program was not an attempt to create a new engineering discipline, but rather to enrich and extend traditional engineering education, so that students might be provided with the tools to understand and deal with problems in technology policy, in addition to traditional skills. Roughly 7 percent of all undergraduate engineers at C–MU participate in a double-major degree program, with EPP as the second major (this amounts to about 100 students a year). Although there exists an ECPD-accredited EPP single major program, only a handful of students have taken advantage of that option. The fact that many faculty hold joint appointments also means that most undergraduate students can maintain natural interactions with faculty members who straddle the same interdisciplinary boundaries as they do.

As an example of the composition of a double major program, I have reproduced the suggested curricula for students enrolled in the Metallurgical Engineering and Materials Science single major and for the double major program with EPP, in Table 1. As can be seen, the major courses in the prime discipline are preserved in the double major program, but the electives and some of the specialty

sequences are replaced by certain specific courses or by electives drawn from a selected group of EPP or social analysis electives. I will show you more examples of these shortly. In particular, you will note that the double major program requires participation in two so-called EPP projects. These have the following characteristics:

—The projects are directed at real-world problems that involve technology and public policy;
—Each project is undertaken by a group of about 30 students and lasts one semester;
—The project is organized in such a way that groups of 4 to 8 students can investigate specific aspects of the problem, with coordination of group efforts by student and faculty managers;
—A group of external experts acts as a client for the study and also serves as a review panel which critiques class efforts;
—During the semester three formal oral presentations are given to the review panel and a report suitable for public dissemination is prepared by the end of the project.

The titles of some recent projects are given in Table 2. Projects such as these provide students with the valuable experience of working on real problems and of participating in the type of group study which many may encounter in their subsequent professional careers.

Some examples of EPP and social analysis electives available to students in all of the double major programs are illustrated in Table 3. The course entitled Materials Policy Analysis has been my own contribution to the undergraduate curriculum. It was offered for the first time this spring as a course specifically aimed at straddling the interests of students in the departments of Metallurgical Engineering and Materials Science (MEMS) and of EPP. About 25 students attended the course; of these two thirds were EPP double majors and one third MEMS single major students.

The outline for the Materials Policy Analysis course is given in Table 4. As shown in this table, the course covered some of the major issues which have been of concern in the materials policy arena over the past decade. The course was designed for engineers and required some prior understanding of structure-property relationships in materials, and of the application of materials in engineering design, as these issues were woven into the consideration of problem areas and policy options, wherever possible.

It is generally agreed that subjects which are introduced to students during the formative years of undergraduate education tend to make a lasting impression and are more likely to be compacted and become part of the "conventional wisdom" of the recipients. Thus, the offer of such courses at the undergraduate level is more likely to have a lasting impact on engineering thinking, in the long run, than academic research activities aimed at specific problem areas.

Now this course is certainly not unique, and I am certain that courses with a similar flavor are taught at a number of academic institutions. In the short time that I had to prepare this paper it was not possible to conduct any kind of thorough national survey to determine how widespread such courses might be (although I believe such a survey would be very worthwhile). However, I did con-

tact a few individuals in academia who are known to have interests in this field and was able to obtain a small sample of materials and minerals policy related teaching activities. These are summarized in Table 5.

THE GRADUATE PROGRAM AND RESEARCH ACTIVITIES

The graduate program in EPP is built upon a research oriented Ph. D. degree. The Department does not support a terminal Master's program, but a joint Master's degree can be obtained with any of the other five engineering departments, along lines similar to the double major undergraduate program. Students enrolled in the Ph. D. program are expected to take 3 to 4 graduate courses in each of three areas: the student's own area of technical specialty, the area of social science and analysis, and a group of courses offered in EPP. There are presently 25 students working towards a Ph. D. in the Department (one of whom is planning to do research in materials policy) and thus far 5 students have completed Ph. D. studies since the graduate program was initiated in 1976.

Research in EPP is focused primarily in eight areas:

—Environmental systems;
—Energy systems;
—Product safety and product liability;
—Social aspects of computer and telecommunications technologies;
—Arms control and disarmament;
—Toxic substance management and control;
—Automation, robotics and productivity;
—Materials policy.

TECHNOLOGY POLICY RESEARCH

Technology policy research is conducted by government, by the consulting industry and by academia. However there is at least one difference between research performed at academic institutions and other research of this type. Generally speaking, the consulting industry performs research under contract for a particular government agency. As a result, the product of this research tends to be highly focused on issues pertaining to the specific sponsoring agency. This is equally true of much of the government's own technology policy research. In contrast, academic research in this field tends to be unfocused, especially when the funds for this research are provided by benevolent foundations. (For example, the Sloan Foundation and the Exxon Education Foundation have provided EPP with generic funding to develop the area of technology policy). Under these conditions one can expect academic research to produce more generalizable insights into the technology policy area. Furthermore, with graduate student involvement as an inextricable part of academic research, it is difficult to perform research that must adhere to strict timing deadlines. This more open-ended time frame for the execution of research provides an opportunity to pursue the interesting and unforeseen issues which frequently emerge when research is undertaken.

The materials policy activity at C–MU is young enough that no serious research is as yet underway. We are beginning to develop

ideas which will hopefully lead to the initiation of research in the near future. If one attempts to gauge research activity on the basis of published literature, one finds that the bulk of academic research of relevance to materials and minerals policy is currently being conducted by mineral and resource economists, rather than by technologists. This is perhaps not too surprising since policy-related research in both government and the consulting industry tends to be dominated by an economics approach to policy analysis. Using the contributions published in the periodical *Materials and Society* during 1981 as an index, one finds that about 40% of the contributions came from academia and about 30% each from government and from other sources (including industry, consulting firms and miscellaneous sources). While it is clear that this "index" cannot be taken to represent the respective shares of research activity in those three sectors, it does indicate that a nucleus of interest in materials and minerals policy research is already in existence at academic institutions.

CONCLUDING REMARKS

I would like to conclude by reiterating that from the vantage point of C–MU, we view the role of academia in materials and minerals policy as being basically two-fold. The first role is education, and is directed towards the training of a new generation of engineers who have been sensitized to the impact of materials, minerals and related technological activities on society, and have been provided with tools to deal with policy problems in this area. The second role is one of research. This is aimed at the extension or application of methodologies developed in the context of conventional engineering research to problems which lie at the materials-society interface, the ultimate objective being to provide the policy-maker with improved means of distinguishing between alternatives.

TABLE 1

Suggested Curriculum — Metallurgy and Materials Science and Engineering and Public Policy

Metallurgy and Materials Science — Single Major

Sophomore Year

	Fall	Units
21-259	Methods of Applied Math I	9
33-123	Physics III	10
27-211	Thermodynamics I	9
–	Technical Elective or 24-102	9
–	H&SS and FA Elective	9
		46

	Spring	
21-260	Methods of Applied Math II	9
27-202	MMS Lab I	9
27-216	Transport and Kinetics	12
15-104	Introduction to Computing A	9
–	H&SS and FA Elective	9
		48

Junior Year

	Fall	Units
27-331	Physical Metallurgy I	12
27-313	Thermodynamics II	9
27-301	MMS Lab II	9
24-102 or	Statics of Deformable Solids	
–	Technical Elective	9
–	H&SS and FA Elective	9
		48

	Spring	
27-332	Physical Metallurgy II	9
27-322	Process Metallurgy	12
39-300	Analysis, Synthesis and Evaluation	12
–	Technical Elective	9
19-451	H&SS and FA Elective	9
		51

Senior Year

	Fall	units
–	Specialty Sequence I	9
–	Technical Elective	9
27-441	Deformation of Materials	9
27-450	Seminar	3
–	H&SS and FA Elective	9
–	Free Elective	9
		48

	Spring	
–	Specialty Sequence II	9
–	Technical Elective	9/12
27-442	Plasticity and Fracture of Materials	9
27-402	Project Lab	9
–	H&SS and FA Elective	9
		45/48

Minimum number of units required for degree: 381.

Metallurgy and Materials Science/ Engineering and Public Policy — Double Major

Sophomore Year

	Fall	Units
	Same	9
	Same	9
	Same	9
19-101	EPP Sophomore Seminar	3
24-102	Statics of Deformable Solids[1]	
or		
–	Technical Elective[1]	9
88-200	Introduction to Models in Social Sciences	9
		48

	Spring	
	Same	9
	Same	9
	Same	12
	Same[2]	9
73-100	Principles of Economics	9
		48

Junior Year

	Fall	Units
	Same	12
	Same	9
	Same	9
36-211	Probability Statistics I	9
–	Social Analysis Elective	9
		48

	Spring	
	Same	9
	Same	12
19-451	EPP Project[3]	12
–	EPP Elective	
or		
–	Technical Elective[4]	9
–	Social Analysis Elective	9
		51

Senior Year

	Fall	Units
19-452	EPP Project[3]	12
–	EPP Elective	9
	Same	9
–	Social Analysis Elective	9
36-212	Probability and Statistics II	9
		48

	Spring	
–	EPP Elective	9
–	EPP Elective	9
	Same	9
–	Technical Elective	9
–	Social Analysis Elective	9
		45

Minimum number of units required for degree: 384.

NOTES:

[1] 27-131, Material Science (technical or college elective) is required for graduation and as a pre- or co-requisite to 27-202. 24-102 should be taken by the Fall semester of Junior year. It is a pre-requisite to 27-441.

[2] If 15-104 was taken in the freshman year, this slot may be used for 27-101 (a MMS technical elective) 27-101 counts as an EPP elective.

[3] The EPP Project courses, 19-451 and 19-452 replace 39-300 and 27-402.

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TABLE 2.—*Examples of recent topics for EPP projects*

Strategies for Improving Safety in Underground Coal Mines (Spring 1980).
Hazardous Waste Management in Pennsylvania (Fall 1981).
Social and Economic Impacts of Siting a High-Level Radio Active Waste Repository (Fall 1981).
Social Impact of Robotics (Spring 1981).
Fire Safety: A Comparative Risk Assessment (Spring 1981).
Automobile Recycling: An Issue for America (Fall 1982).

TABLE 3

Selected Engineering & Public Policy Electives

Energy, Technology and Society.
Engineering Economics and Optimization.
Environmental Issues and Problems.
Materials Policy Analysis.
Law and the Engineer.
Transportation Policy Analysis.
Technical and Political Issues in Arms Control and Defense Policy.

Selected Social Analysis Electives

Demographic Approaches to Public Issues.
Labor Economics.
Structures of Interpersonal Behavior.
Organizational Decision Making.
Regulatory Processes.
Philosophy of Technology.
Policy Analysis: Analytical Models for Policy Analysis.

TABLE 4

Course Outline for Materials Policy (19-410)—Spring 1982

Introduction.
Applications of materials in high-technology—overview.
The geography of minerals occurrence; production and consumption.
    Geology of ore deposits.
    U.S. and World consumption.
    Geographical distribution of reserves/resources.
    Geographical distribution of minerals and materials production.
Extraction of metals from ores.
Geopolitics of minerals.
    The Soviet bloc.
    Southern Africa.
    China.
    East-Asia/Oceania.
    Latin America.
    North America.
Resource exhaustion—reality or myth?
    "The Limits to Growth"—a Catastrophist argument.
    "The Age of Substitutability"—a Cornucopian argument.
Report of the National Commission on Materials Policy, 1973.
Review of selected materials-oriented legislation.
Assessment of vulnerability to supply disruptions.
    Sources of supply disruptions—cartels.
    Vulnerability indices.
Options for diminishing vulnerability.
    Stockpiling.
    Materials conservation/recycling.
    Materials substitution.
    Development of domestic resources.
    Ocean bed resources.
Vulnerability to supply disruptions—some case studies.
    Chromium.
    The platinum group metals.

TABLE 5.—SOME EXAMPLES OF COURSES RELATING TO MATERIALS/MINERALS POLICY

Course title	Institution	Instructor (or contact)	Level
Introduction to Mineral Resources—21st Century Industrial Ethics.	Columbia	J. K. Tien	Undergraduate.
Mineral Policy Analysis	Penn State	William Vogely	Graduate.
Economics of Mineral Extraction and Exploration	Purdue	F. T. Sparrow	Graduate/Undergraduate.
Materials Resources Policy	Vanderbilt	R. T. Nash	Undergraduate.
Materials and the Economy	VPI	Walter Hibbard	Do.

Strategic Materials: A Foreign Viewpoint*

The Henniker Conferences established a forum for the discussion of issues relating to strategic minerals and materials. During the last twelve years concerns have been voiced in the USA regarding the supply of these strategic minerals and materials especially following the oil crisis of 1973. This is, I believe, the first contribution by a representative from a country which is a supplier of these strategic minerals and materials. I welcome the opportunity to present a foreign supplier's viewpoint but should point out that the views expressed have a strong South African flavour and are probably not representative of all foreign minerals suppliers to the USA.

I have made use of information supplied to me by the South African Department of Foreign Affairs and Information, the South African Minerals Bureau, the Council for Minerals Technology in South Africa and the Middelburg Steel and Alloys Company in South Africa and I am most grateful to them for their assistance.

The objectives of the presentation are the following:

(i) To present an overview of the South African minerals industry.

(ii) To discuss important factors which influence the South African viewpoint.

(iii) To identify present trends and future developments.

Overview of the Minerals Industry of South Africa

The South African minerals industry is one of the most highly structured, technologically efficient and financially self-sufficient in the world. During 1979 more than 900 mines and quarries were in operation, some of which represent the world's richest, largest and deepest. The mines offered employment to more than 772,000 people and paid out some R2 440 million in wages. More than 50 different mineral commodities were produced of which the sales value in 1979 amounted to R9 768 million, an all-time record, and no less than 42 percent higher than in 1978. Total historic value of the mineral sales to date, that is since 1852, amounts to more than R62 000 million of which gold accounts for more that 60 percent, its contribution in 1979 still being of the same order.

The role played by South Africa as a Minerals Supplier is highlighted in Tables 1, 2, and 3. Table 1 presents data on mineral re-

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serves for 1981, Table 2 presents data on mineral production in 1980 while Table 3 presents mineral export data for 1980. Table 3 is particularly important as it underlines the South African role as an exporter of minerals and processed minerals. The USA and USSR are the largest producers of minerals but export little, hence they are strategic suppliers only to themselves and have no global supply role. 1981 production data for selected mineral commodities are listed in Table 4.

In summary, in the context of mineral supply meaning availability of minerals for consumption abroad, South Africa therefore has a particularly important role to play, for:

South Africa is the world's largest source of supply of the precious metals and minerals gold, platinum and gem diamonds; of the steel and alloying metals chrome, manganese and vanadium; and one of the three most important suppliers of the energy minerals, coal and uranium.

South Africa is one of the world's major sources of industrial metals and minerals like antimony, asbestos, fluorspar, vermiculite and andalusite, and an important supplier of titanium minerals, copper, lead, nickel and silver.

South Africa is one of the world's largest suppliers of processed mineral products, in particular of ferro-chromium, ferro-manganese and platinum metal, as well as vanadium slag and pentoxide, manganese metal and antimony trioxide, and a major source of titanium slag and phosphoric acid supply.

Let us now consider the internal factors which dictate our stance as a minerals supplier.

FACTORS WHICH INFLUENCE THE SOUTH AFRICAN VIEWPOINT

The economy is a dynamic one and as it is based on free enterprise, it offers many rewards. The mining industry is however not the entire story. One vital component is a sophisticated minerals transport infrastructure which ensures that the minerals mined do reach their destinations in the Western World. In addition, an extensive advanced agricultural industry exists which makes South Africa almost self sufficient in its food requirements and in certain commodities a net exporter. It is furthermore often not realised that a well developed industrial sector exists. Manufacturing industry contributes 24 percent to the gross domestic product and it employs 1.3 million people (about the same number as is the case in the Netherlands). Over the past two decades this sector expanded at an annual rate of about 7 percent and in recent years it has increased by as much as 9 percent per annum. During the present year this is expected to be slightly lower due primarily to the worldwide recession.

However, South Africa has a tarnished reputation in the field of human relations and human rights. This is one of the reasons why in spite of the previously mentioned positive economic and mineral wealth factors, the supply of these strategic materials is often viewed with some concern in the USA. This is an area which is currently receiving much attention in South Africa and it must be discussed.

South Africa suffers an imbalance between skilled labour on the one hand and semi-skilled or unskilled labour on the other hand. This problem has received special attention over the last number of years with the result that a totally new manpower strategy is now emerging. This includes inter alia:

New organisational structures to ensure proper planning.

Strong emphasis on training including financial assistance by the State and fundamental reforms in education systems.

Abrogation of restrictive legislation.

The general picture of South Africa at this moment is one of consultation, economic and political development, peaceful coexistence, constructive developing race relations and confidence in the future. Evolutionary and orderly change is taking place and there is a determination to succeed. In giving this assurance we should not belittle the complicated problems which we face in South Africa for one moment. In this, however, South Africa is not unique.

A major factor in this growth compulsion is our very fast-expanding population and the need to supply job opportunities to all workseekers. Seen from the viewpoint of the creation of job opportunities, the real gross domestic product must increase by at least 5 percent per annum. And prerequisite for that sort of economic growth is, among many other factors, active participation in international trade and, furthermore, active international participation in the South African economy.

That then, in plain and simple terms, is the one side of the coin of interdependence. South Africa, and in particular her hundreds of thousands of Black workseekers entering the labour market each year, needs full scale economic interaction with the Western World. But then there is the other side of the coin. While it is true that South Africa needs investment, know how, machines and many other commodities, it is equally true that our trading partners need commodities, vital to their economic well-being and prosperity, which we can supply.

With this background, logic dictates that the various parties which are thus interdependent should positively and actively pursue policies and programmes aimed at ensuring continued and expanding co-operation and interaction.

In spite of the logic promoting constructive interdependence, many of South Africa's customers remain concerned about their security of supply. For this reason, the Minister of Mineral and Energy Affairs, The Hon. F. W. de Klerk, recently issued a clear and unambiguous statement. It reads as follows:

> The appropriate mineral strategy for South Africa at this time, taking into account the present hostile international attitude and increasing pressure on South Africa, is not to use our mineral weapon as a threat. Such action can only be effective, and doubtfully so, for short term political gain.
>
> We have over many years build up our present reputation as a reliable supplier and only under extreme provocation where our very existence is threatened, should the mineral weapon be invoked.

PRESENT TRENDS AND FUTURE DEVELOPMENT

A number of years ago it was realised that because of South Africa's favourable coal reserves our energy costs were substantially lower than elsewhere and this favoured a move into energy intensive minerals processing. This resulted in the development of an extensive ferro-alloys industry. Some of the production figures and how they influence the USA are summarised in Table 5. The net influence of this development is that by 1981, total ferro-alloy production exceeded 1.2 million tons with a value of R500 million. Ferrochromium accounted for approximately half the total. The total capital investment in ferro-alloy plants between 1974 and 1981 was between R2,3 and R2,4 billion. Total labour force employed is approximately 12,000.

The advantage of promoting the benefication of South African ores to South Africa and the Western World are obvious and the question was then posed—"What next?"

An excellent example of a successful materials development and promotion project on a world scale is that of the Climax Molybdenum Company in the USA.

While pure molybdenum metal finds a number of applications, its largest use is as an alloying element in upgrading iron, steel and non-ferrous super-alloys. In addition, significant amounts of molybdenum compounds are used as lubricants, pigments and catalysts.

Climax Molybdenum was originally involved in the exploitation of the large deposits of molybdenum in the free world, which are located in the United States, Canada and Chile. Because of its strong interest in selling the molybdenum which it mined, the Climax Company set out, some forty years ago, to develop new applications for molybdenum. They established a research organization which had as its prime task, the promotion of the element molybdenum in a number of different applications. Because of the fundamental research done and the large amount of information generated by this research organization, technologists and engineers everywhere have come to use molybdenum modified steels and molybdenum products in a number of applications simply because they have been so well researched by the Company promoting its sale.

One of the Climax slogans is: "Since the Climax mine was opened in 1918, no-one has thought of molybdenum without thinking of Climax and we intend to keep it that way."

There can be no doubt that over a period of years the approach has been successful and that they have really lived up to the slogan. Molybdenum is widely used today in a number of applications which resulted from their research, and this has meant increasing molybdenum sales.

Obviously South Africa can learn a lot from the Climax Molybdenum Company. For a number of years vanadium producing companies have been involved in Vanitec and manganese producing companies have been involved in the Manganese Centre. These organizations have attempted to promote vanadium and manganese in much the same way as the Climax Molybdenum Company promoted molybdenum.

At this stage let me describe the situation with reference to chromium. As has been described, South Africa has extensive deposits of chromite. How can these be used to best advantage of South Africa, all her people and her main trading partners?

Recently a Chromium Centre was established in South Africa by the Council for Minerals Technology in conjunction with the South African Chromium Industry.

One of the main aims of the centre is the stimulation of research and development work on new uses for chromium in metallurgical and other fields. The centre started on a modest scale by collecting, monitoring, and disseminating information on a world-wide basis on the production and uses of chromium in its various forms.

Much of the present materials research and development work in South Africa is now concentrated into the physical metallurgy of chromium containing alloys. At the same time a need arose in the gold mining industry for more sophisticated materials. It should be remembered that the South African gold mines are among the deepest in the world with an average depth of 1.7 km. In using more sophisticated mining equipment it soon became apparent that there was a great need for a corrosion resisting steel as an alternative construction material where mild and low alloy carbon manganese constructional steel have inadequate corrosion resistance, and where coatings such as paint, galvanising etc. are inappropriate due to thermal, mechanical or chemical degradation.

The above mentioned drive to promote chromium and the marketplace demand have resulted in the development of 3CR12, a low-cost chromium containing corrosion resisting steel, which was developed from AISI 409 by the Middelburg Steel and Alloys Company. The material has a very fine stable microstructure which is derived from the duplex elevated-temperature microstructure and provides attractive mechanical properties combined with adequate corrosion resistance and weldability. The composition of 3CR12 is listed in Table 6. Let us review some of its properties as an example of the progress made in this field.

The mechanical properties of 3CR12 are affected by the carbon and nitrogen content of the steel, as well as by the stabilization ratio. Carbon, nitrogen and nickel increase the hardness and strength of the steel, due to the increase in martensite content, and some solution hardening. After hot rolling the banded structure of ferrite and martensite requires annealing to achieve optimum and isotropic strength, ductility and toughness. Subcritical annealing is used to achieve softening.

The hot strength of 3CR12 is acceptable for many applications at temperatures where mild steels are subject to scaling, or have inadequate strength.

The corrosion resistance of 3CR12 has been tested in numerous applications involving dilute acid, base and salt solutions. The corrosion rate in many of these applications is low enough to consider use of the material as an alternative to coated mild steels.

The low chromium content of 3CR12 causes the passive film to form rather slowly and discontinuously on the surface. This can be an advantage, but can lead to rather high corrosion rates with the material. It is essential to passivate 3CR12 using dilute nitric acid solutions before service in a corrosive environment. The pitting cor-

rosion resistance of 3CR12 is of particular importance. Since the passive film on 3CR12 is discontinuous, pitting is a relatively minor problem. 3CR12 is not subject to stress corrosion cracking in chloride, nitrate or hydroxide solutions.

The duplex nature of 3CR12 at high temperatures causes a considerable portion of the HAZ to transform to martensite during subsequent rapid cooling. The Ms temperature is depressed by rapid cooling rate, but remains well above room temperature. The formation of the second phase in the HAZ causes an effective reduction in the grain size.

So much for 3CR12 which is just one of the products to result from the alloy research and development programmes.

Finally in our own laboratory we have been trying to understand some of the influences of specific alloying elements. Some work has been carried out on the replacement of molybdenum. This work was originally stimulated because of a total lack of commercially exploitable molybdenum ore deposits. The experiments are designed to measure and understand the role of molybdenum in promoting hardenability, temper embrittlement and pitting corrosion. Following this, elements such as chromium, manganese and vanadium will be studied to highlight their role. Figures 1 and 2 show the effect of the replacement of Mo in EN19 with Mn and Cr and the influence on hardenability. These are obviously promising preliminary results both in promoting chromium and manganese, but also in solving a potential problem if molybdenum suddenly became unavailable.

SUMMARY

To summarise I can therefore say that South Africa has a unique store of valuable minerals. Coupled to this is a requirement typical for developing or third world countries to create employment opportunities for fast growing populations. This necessitates a positive stance as a reliable supplier of minerals and processed minerals (such as ferro-chrome) to the World. In addition we are at present actively involved in research and development to promote the use of our minerals. This research and development is designed to make available reference data on processed materials required by engineers in order to make best use of these materials. This research and development is based on the interdependance of nations in the Western World and is designed to promote collaboration and constructive interdependance.

ACKNOWLEDGMENTS

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TABLE 1.—THE ROLE OF THE REPUBLIC OF SOUTH AFRICA † IN WORLD MINERAL RESERVES, 1981

Mineral commodity	Unit of quantity	RSA reserves	Western World		World	
			Rank	Percent	Rank	Percent
Manganese ore [4]	tx10[6]	12,140	1	95	1	81
Platinum Group Metals [1 5]	t	26,700	1	86	1	72
Gold [1]	t	15,000	1	61	1	49
Chrome ore [6]	tx10 [6]	2,400	1	58	1	58
Vanadium [1 7]	tx10 [3]	5,400	1	48	2	29
Andalusite/sillimanite	tx10 [3]	104,000	1	47	1	38
Fluorspar [8]	tx10 [3]	31,100	1	46	1	34
Vermiculite	tx10 [3]	73,000	2	29	2	28
Diamond	car x 10 [3]	72,000	2	24	2	22
Uranium [1 9]	t	356,000	2	16	NA	NA
Zirconium [1]	tx10 [3]	4,000	3	13	4	11
Coal [3]	tx10 [6]	51,000	3	13	4	10
Phosphate [2]	tx10 [6]	1,800	3	9	3	9
Antimony [1]	t	300,000	3	8	3	7
Asbestos	tx10 [3]	7,800	3	8	4	6
Titanium [1]	tx10 [3]	33,000	4	17	4	16
Nickel [1 5]	tx10 [3]	5,480	4	11	5	9
Zinc [1]	tx10 [3]	12,000	4	5	5	5
Lead [1]	tx10 [3]	6,200	4	4	5	4
Iron ore [7]	tx10 [6]	9,500	6	6	7	4
Silver [1]	t	8,700	6	4	7	3
Cobalt [1]	t	66,500	6	2	8	2
Copper [1]	tx10 [3]	6,300	10	1	12	1
Tin [1]		(*)	12	<1	12	<1

† Excludes Bophuthatswana, Ciskei, South West Africa/Namibia, Transkei and Venda. *Classified information.
[1] Contained metal. [2] Contained concentrate. [3] Bituminous and anthracite, recoverable. [4] In situ. [5] To 600 metres depth.
[6] To 300 metres depth. [7] To 30 metres depth. [8] Contained CaF_2. [9] Up to US $50/lb U_3O_8.

Source: South African Minerals Bureau.

Notes: Western World excludes COMECON member countries but includes China and nonalined countries.

TABLE 2.—THE ROLE OF THE REPUBLIC OF SOUTH AFRICA † IN WORLD MINERAL PRODUCTION, 1980 r

Mineral commodity	Unit of quantity	RSA production	Western World		World	
			Rank	Percent	Rank	Percent
Gold [1]	kg	672,874	1	68	1	52
Manganese metal		(*)	1	52	NA	NA
Vanadium [1]		(*)	1	49	1	35
Andalusite/sillimanite	t	212,710	1	47	1	40
Chrome ore	t	3,414,410	1	43	1	33
Manganese ore	t	5,695,426	1	33	2	21
Ferrochromium	t	754,854	1	31	1	23
Platinum group metals		(*)	2	36	3	20
Vermiculite	t	185,699	2	35	2	33
Diamond [4]	carats	8,521,682	2	29	3	21
Antimony [1]	t	13,069	2	23	2	20
Fluorspar	t	522,718	2	13	2	10
Ferromanganese		(*)	2	13	3	10
Asbestos	t	276,734	2	10	3	6
Zirconium [2]		(*)	2	10	2	10
Uranium [1]	t	6,187	3	14	NA	NA
Titanium		(*)	3	14	3	13
Coal [3]	tx10 [3]	115,120	4	5	6	3
Phosphate [2]	t	3,282,000	6	3	7	2
Iron ore	tx10 [3]	26,312	8	4	9	3
Silver [1]	kg	222,188	8	3	10	2
Copper [1]	t	200,683	9	3	11	3
Tin [1]	t	2,913	10	1	11	1

TABLE 2.—THE ROLE OF THE REPUBLIC OF SOUTH AFRICA † IN WORLD MINERAL PRODUCTION, 1980 r—Continued

Mineral commodity	Unit of quantity	RSA production	Western World		World	
			Rank	Percent	Rank	Percent
Lead [1]	t	86,059	11	3	13	2
Nickel [1]		(*)	12	2	14	2

r Revised. † Excludes Bophuthatswana, Ciskei, South West Africa/Namibia, Transkei, and Venda. * Classified information.
[1] Contained metal. [2] Contained concentrate. [3] Bituminous and anthracite. [4] Gem and industrial.

Source: South African Minerals Bureau.

Notes: Western World excludes COMECON member countries but includes China and nonalined countries.

TABLE 3.—THE REPUBLIC OF SOUTH AFRICA'S ROLE IN WORLD MINERAL EXPORTS, 1980

Mineral commodity	South Africa's exports (metric tons)	Western World		World	
		Rank	Percent	Rank	Percent
Platinum group metals (kilograms)	([1])	2	42	3	25
Vermiculite	156,072	1	80	1	78
Vanadium	([1])	1	67	1	63
Gold (kilograms)	672,485	1	68	1	57
Manganese metal	([1])	1	67	1	59
Ferrochrome	([1])	1	48	1	44
Andalusite/sillimanite	106,786	1	58	NA	NA
Chrome ore	1,237,203	1	48	1	31
Manganese ore	([1])	1	43	1	33
Ferro manganese	([1])	1	20	1	16
Diamonds (gem, industrial) carats	8,450,245	2	25	NA	NA
Fluorspar	469,071	2	27	3	20
Uranium	([1])	3	24	NA	NA
Antimony trioxide	([1])	NA	NA	NA	NA
Zirconium	([1])	2	23	NA	NA
Asbestos (fiber)	([1])	2	14	3	10
Coal (anthracite, bituminous)	29,150,234	3	17	5	12
Antimony	12,534	2	23	2	23
Iron ore	([1])	6	5	9	4
Nickel (metal)	([1])	7	4	10	3
Copper (metal)	([1])	8	3	9	1
Tin (metal) kilograms	694	9	3	10	3
Silver (metal) kilograms	191,290	10	2	14	1
Lead (concentrates)	64,922	7	10	11	10
Zinc	26,160	17	1	NA	1

[1] Classified data.
NA—Not available.

Source: Minerals Bureau of South Africa.

TABLE 4.—1981 PRODUCTION DATA FOR SELECTED COMMODITIES

Commodity	Production (quantity)	Export value
Manganese ore	5 million tons	R165 × 10^6.
Gold	655, 728 kg	R8.5 billion.
Diamonds	9.5 × 10^6 carats	R340 × 10^6.
Chrome (ore + concentrates)	2.8 × 10^6 tons	R77.2 × 10^6.

TABLE 5.—SELECTED MINERAL AND FERRO-ALLOY EXPORTS TO THE UNITED STATES

Mineral commodity	South African share of U.S. import sources		
	1974–77	1978	1980
Chrome ore	35	48	38.0
Ferrochrome	38	79	76.3
Manganese ore	9	4	49.7
Ferromanganese	30	45	39.0

Sources: U.S. Nonfuel Minerals Policy Review, USBM commodity data summaries, 1979–80.

TABLE 6.—COMPOSITION OF ALLOYS

Alloy	C	Si	Mn	Cr	Ni	Ferrite factor	N	Ti
AISI 409	[1] 0.08	[1] 1.0	[1] 1.0	10.5–11.75	[1] 0.5	13.3/14.6	.....	[2] 6xC
BSC Hyform 409 [3]	0.045	0.6	0.3	11.5	.....	16.7	.....	0.5
Commercial run-of-mill alloy	0.025	0.45	0.80	11.45	0.40	11.11	0.013	0.21
SX 3 CR 12	0.025	0.40	0.90 (S<0.020,	11.5 P<0.015)	0.60	11.5	0.020	0.20

[1] Maximum.
[2] Minimum.
[3] Typical composition given in British Steel Corp. pamphlet BSS003 8/78.2MR.

FIGURE 1.—Effect of replacing molybdenum with manganese in EN19 steel

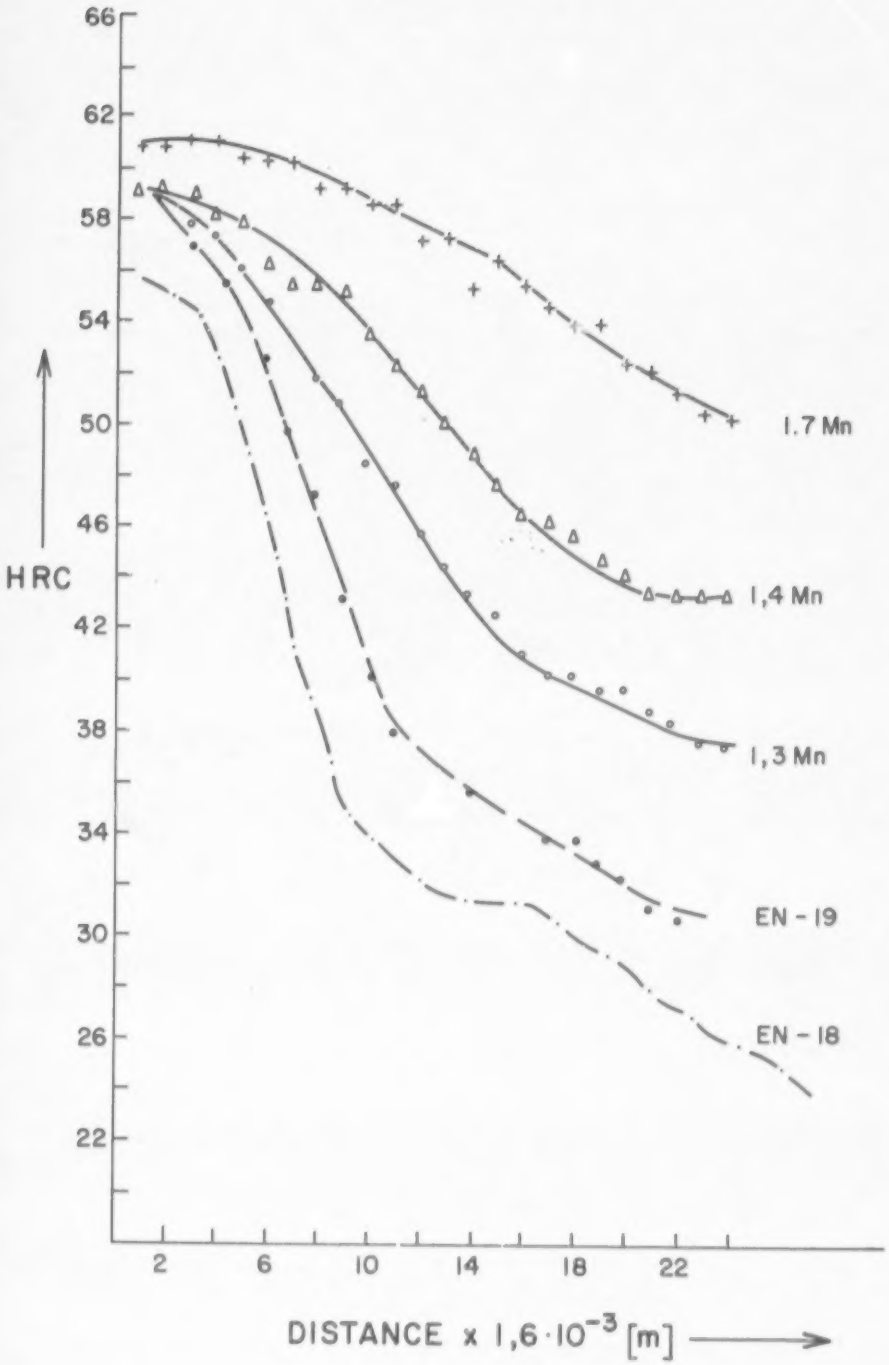

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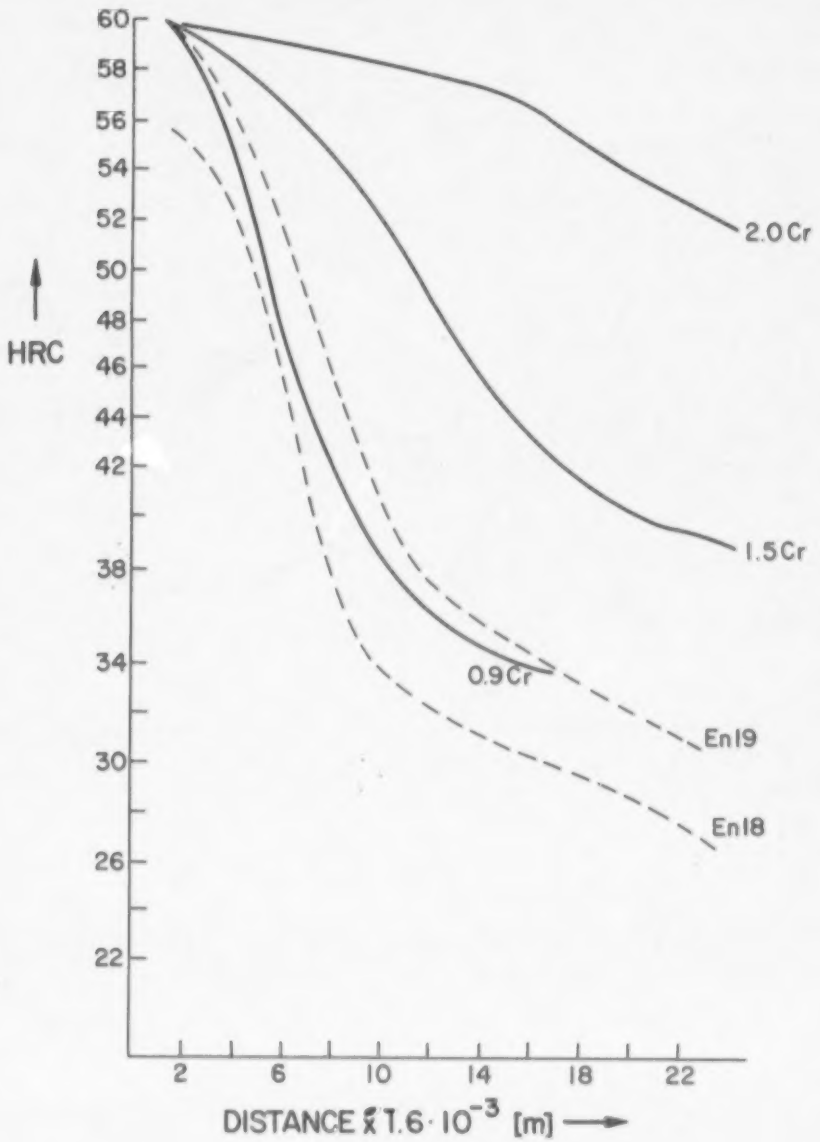
FIGURE 2.—Effect of replacing molybdenum with chromium in EN19 steel



IV. PANEL—RESPONSES TO THE NATIONAL MATERIALS AND MINERALS POLICY RESEARCH AND DEVELOPMENT ACT OF 1980

Strategic and Critical Materials: DOD Needs and Supply Problems*

*By Richard E. Donnelly, Director, Industrial Resources, Office of the Under Secretary of Defense (Research & Engineering)

INSTITUTE FOR DEFENSE ANALYSES
SCOPE OF STUDY

MAJOR EMPHASIS

- DOD DEMAND AND SUPPLY
  - DOD REQUIREMENTS
  - SUPPLY SOURCES
  - INDUSTRY CAPABILITY
- TECHNICAL OPTIONS TO MEET DEMANDS
  - EXPLORATION AND RECOVERY
  - CONSERVATION
  - RECYCLING
  - SUBSTITUTION

MINOR EMPHASIS

- LEGISLATIVE POLICIES AFFECTING MATERIALS
  - FUNDING AUTHORIZATION
  - FOREIGN POLICY
  - FINANCIAL ASSISTANCE
- ADMINISTRATIVE PRACTICES RELATING TO MATERIALS
  - PROCUREMENT
  - ENVIRONMENTAL (EPA, OSHA)
  - TRADE

INSTITUTE FOR DEFENSE ANALYSES
MATERIALS INCLUDED IN STUDY

MATERIAL	CRITERIA FOR SELECTION
BERYLLIUM*	SINGLE SUPPLIER, SUBJECT TO OSHA REGULATIONS ESSENTIAL FOR GUIDANCE SYSTEMS, ETC.
CARBON FIBER*	NEW TECHNOLOGY, NOT STOCKPILED SUBSTITUTE FOR SOME OTHER MATERIALS
CHROMIUM*	IMPORT DEPENDENT, OFF-SHORE FERROCHROME ESSENTIAL FOR BROAD DEFENSE USES
COBALT*	IMPORT DEPENDENT, POTENTIAL U.S. SOURCES ESSENTIAL FOR BROAD DEFENSE USES
GERMANIUM	PARTLY IMPORT DEPENDENT, NOT STOCKPILED ANTICIPATED INCREASE IN DEFENSE USES
MANGANESE	IMPORT DEPENDENT ESSENTIAL TO STEEL INDUSTRY AND BROAD DEFENSE USES
PLATINUM	IMPORT DEPENDENT ESSENTIAL CATALYST IN SUPPORT INDUSTRIES
QUARTZ*	PARTLY IMPORT DEPENDENT SPECIAL PURPOSE OPTICS AND ELECTRONICS SMALL QUANTITY, HIGH RELIABILITY NEEDS
TANTALUM*	IMPORT DEPENDENT ESSENTIAL FOR ELECTRONICS AND ENGINES
TITANIUM*	PARTLY IMPORT DEPENDENT ALLEGED PROCESSING CAPACITY PROBLEMS

*INITIAL EMPHASIS WAS PLACED ON THESE MATERIALS

ESSENTIAL DEFENSE USES OF SOME MATERIALS

SYSTEM	MATERIAL									
	BE	CARBON FIBER	CR	CO	GE	MN	PT	QUARTZ	TA	TI
SATELLITES	X	X	X	X		X		X	X	X
AIRCRAFT	X	X	X	X		X				X
ENGINES			X	X		X			X	X
HELICOPTERS		X	X	X	X	X				X
MISSILES	X	X	X	X	X	X		X	X	X
TANKS			X	X	X	X		X	X	X
ARTILLERY			X	X		X				
AMMUNITION			X			X				X
SHIPS			X	X		X				
SUBMARINES	X		X	X		X			X	
MINES			X	X		X			X	
ELECTRONICS	X		X	X		X	X	X	X	
SUPPORT INDUSTRIES			X	X		X	X			X

BE – BERYLLIUM
CR – CHROMIUM
CO – COBALT
GE – GERMANIUM
MN – MANGANESE
PT – PLATINUM
TA – TANTALUM
TI – TITANIUM

DOD SUPPLY AND DEMAND

SUPPLY SOURCES

- RAW MATERIALS
  - FOREIGN
  - DOMESTIC
- STOCKPILE
- RECYCLING, RECLAMATION

INDUSTRY CAPABILITY

- BASIC MATERIALS PRODUCERS
- FABRICATORS
- PROCESSING

DETERMINE DOD DEMAND

- WEAPON SYSTEM SURVEY
  - BILLS OF MATERIALS
  - INTERVIEWS
  - SERVICE ESTIMATES
- INDUSTRY ESTIMATES
- ECONOMETRIC MODEL

FINDINGS OF STUDY

- MATERIALS REQUIREMENTS NOT READILY DETERMINABLE
- BROAD RANGE OF MATERIALS REQUIRED FOR NATIONAL SECURITY
- SEVERAL MATERIALS CRITICAL TO DOD; SUPPLY PROBLEMS DIFFER
- INDUSTRIAL BASE INADEQUATE TO SUPPORT EMERGENCIES
- U.S. REGULATIONS, PROCUREMENT PRACTICES DISCOURAGE SUPPLIERS
- DOD SYSTEMS CAN USE MATERIALS MORE EFFICIENTLY
- IMPROVED NATIONAL MATERIALS PLANNING AND COORDINATION NEEDED
- DOD R&D AND MAN TECH PROGRAMS ADDRESSING MATERIALS ISSUES
- STOCKPILING ACT PROVISIONS SATISFACTORY BUT REQUIRE MODIFICATION
- DEFENSE PRODUCTION ACT PROVISIONS SATISFACTORY BUT REQUIRE IMPLEMENTATION

DEFENSE PRODUCTION ACT PROVISIONS ARE ADEQUATE, BUT REQUIRE IMPLEMENTATION

TITLE I — PRIORITIES AND ALLOCATIONS

- PRIORITIES SYSTEMS NOW IN EFFECT
- EXPEDITES DELIVERY OF DEFENSE EQUIPMENT
- PROVIDES STAND-BY CONTROL OF ECONOMY THROUGH ALLOCATION OF CERTAIN MATERIALS
- WIDELY MISUNDERSTOOD
- MANDATORY ACCEPTANCE OF RATED ORDERS RARELY ENFORCED

TITLE III — INDUSTRIAL CAPACITY EXPANSION

- PROVIDES INCENTIVES FOR PRIVATE EXPANSION
- CAN PROVIDE GOVERNMENT WITH MATERIALS FOR STOCKPILE
- CONGRESSIONAL APPROPRIATION OF FUNDS NOW REQUIRED
- NO MAJOR PROJECTS FUNDED SINCE 1967
- FOUR PROJECTS UNDER STUDY
  - DOMESTIC COBALT MINING — GUARANTEED PRICE
  - BAUXITE EQUIVALENT — LOAN GUARANTEES, PURCHASE AGREEMENTS
  - DOMESTIC GUAYULE RUBBER — DIRECT GOVERNMENT PROJECT
  - DOMESTIC TITANIUM — GUARANTEED PRICE

ACTIONS AND OPTIONS TO MEET DOD NEEDS

- TECHNICAL
  - CONSERVATION
  - RECLAMATION
  - SUBSTITUTION
  - SPECIFICATIONS
  - DATA BANKS
  - R&D ON NEW MATERIALS
  - MANUFACTURING TECHNOLOGY
  - NEW MATERIAL RESOURCES
- ADMINISTRATIVE
  - DOD PROCUREMENT PRACTICES
  - MANPOWER/TRAINING ASSESSMENT
  - NATIONAL MATERIALS PLANNING
- LEGISLATIVE
  - DEFENSE PRODUCTION ACT IMPLEMENTATION
  - STOCKPILE REVISION
  - GOVERNMENT REGULATIONS ASSESSMENT

DOD ESTABLISHED CONTINUING SUPPORT OF THE INSTITUTE FOR DEFENSE ANALYSES

- ASSESSING MATERIALS TECHNOLOGY AND PRODUCTION OPTIONS
  - COMPOSITES
  - TITANIUM
  - GERMANIUM
  - GALLIUM
  - COBALT
  - CHROMIUM
  - PLATINUM
  - MANGANESE

PRESIDENT'S PLAN AND REPORT TO CONGRESS ENCOURAGES STIMULATION OF INTERNATIONAL MATERIALS R&D (FREE-WORLD)

- NATO
  - ADVISORY GROUP ON AERONAUTICAL R&D
  - DEFENSE RESEARCH GROUP
- MILITARY TECHNICAL COOPERATION PROGRAM
  - UNITED KINGDOM, CANADA, AUSTRALIA
  - UNITED STATES, NEW ZEALAND
- DEFENSE RELATED SPECIFIC TOPICAL AREA BI-LATERAL
  - INFORMATION EXCHANGE PROGRAMS
  - DATA EXCHANGE AGREEMENTS
  - MEMORANDA OF UNDERSTANDING

PRESIDENT'S NATIONAL MATERIALS AND MINERALS PROGRAM PLAN AND REPORT TO CONGRESS – 5 APRIL 1982

NEW ORGANIZATIONAL EMPHASIS

- CABINET COUNCIL ON NATIONAL RESOURCES AND ENVIRONMENT
  - NATIONAL MATERIALS POLICY COORDINATION
- COMMITTEE ON MATERIALS
  - MATERIALS TECHNOLOGY COORDINATION
  - DEFENSE MATERIALS AVAILABILITY STEERING COMMITTEE
- EMERGENCY MOBILIZATION PLANNING BOARD
  - PREPAREDNESS CAPABILITIES COORDINATION

DOD WEAPON SYSTEM DEVELOPMENT

- BASED UPON EXPECTED THREAT ENVIRONMENT
- DESIGNED TO PROVIDE SUPERIORITY
- PRODUCED TO MEET MISSION REQUIREMENTS

SOME OBJECTIVES

- LONGER RANGE
- REDUCED FUEL CONSUMPTION
- HEAVIER PAYLOAD CARRYING CAPACITY
- FASTER SPEED

CURRENT HIGH-TECHNOLOGY ACHIEVEMENTS IN AEROSPACE MATERIALS AND STRUCTURES

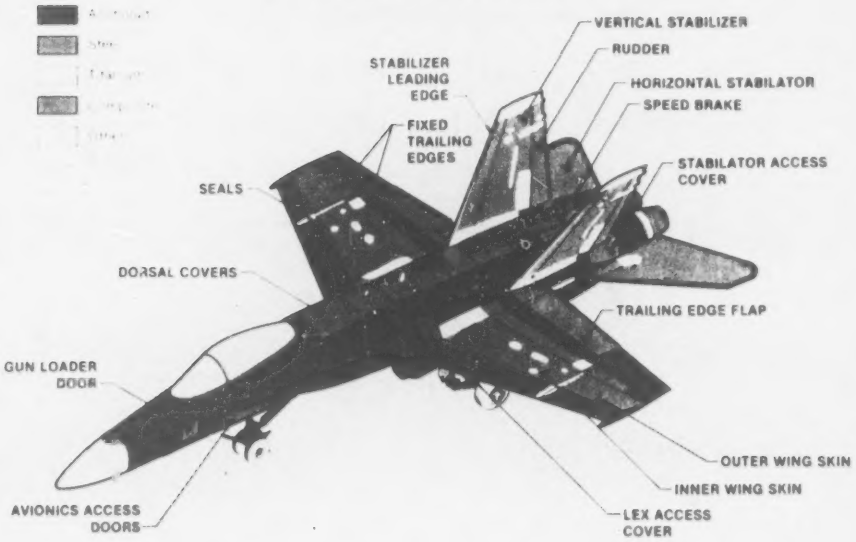
COMPOSITES

- GRAPHITE FIBER
- CARBON/CARBON
- METAL MATRIX

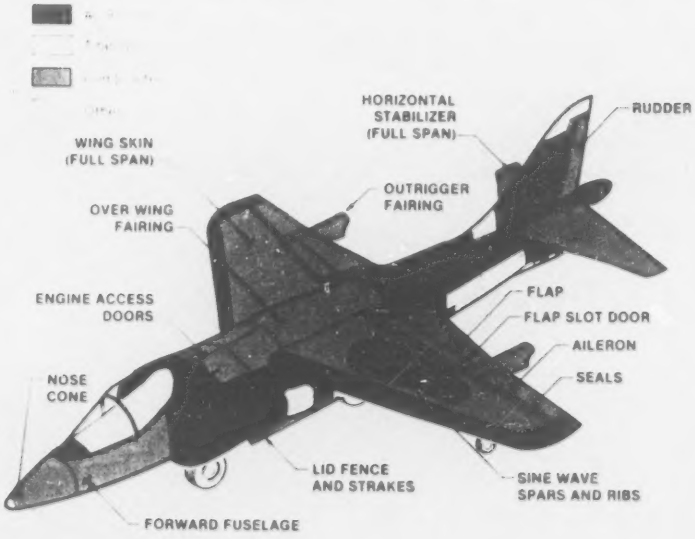
EXAMPLES

PERCENT BY WEIGHT	TACTICAL AIRCRAFT	FIRST FLIGHT
2%	F-15	JULY 1972
10%	F-18	NOV 1978
26%	AV-8B	SEP 1981
33%+	ATF	TBD

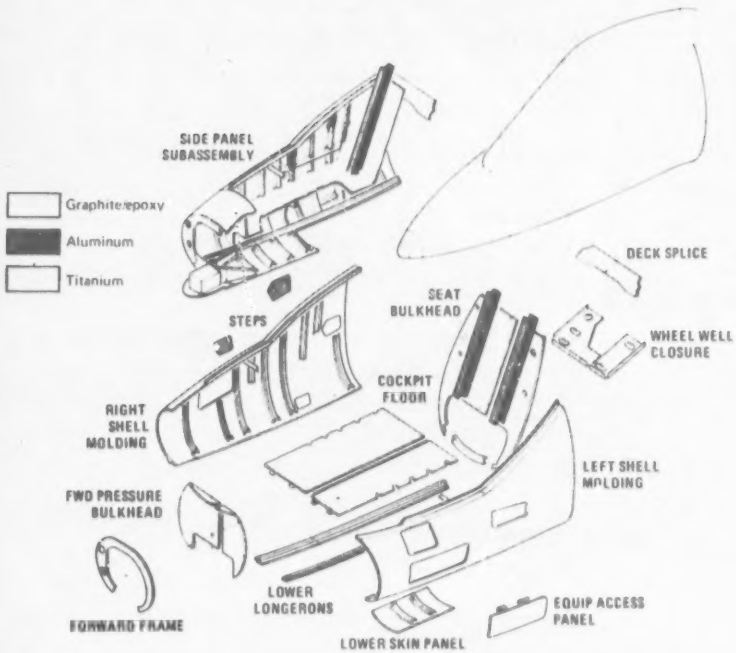
F/A-18
COMPOSITE APPLICATIONS



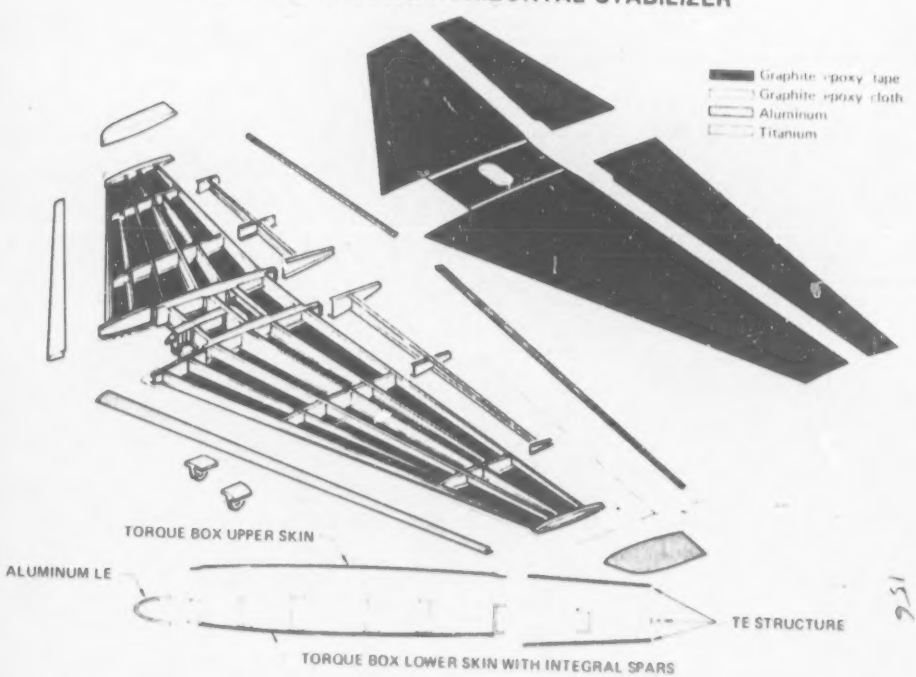
AV-8B
COMPOSITE APPLICATIONS



AV-8B FORWARD FUSELAGE



AV-8B COMPOSITE HORIZONTAL STABILIZER



STRATEGIC & CRITICAL MATERIALS STOCKPILE ACT PROVISIONS ARE ADEQUATE, BUT REQUIRE FUNDING

GOALS

- SUBJECT TO FREQUENT CHANGE
- NEED STABILIZATION
- SHOULD RELATE TO TECHNOLOGY ADVANCES
- ESTIMATING TECHNIQUES NEED REFINEMENT

INVENTORY

- MANY MATERIALS DO NOT MEET GOALS: OTHERS EXCEED GOALS
- ADJUSTMENT REQUIRES AUTHORIZATION BY CONGRESS
- ROTATION NEEDED FOR UPGRADING

QUALITY & FORM

- SOME SPECIFICATIONS OUTDATED OR UNKNOWN
- SOME MATERIALS UNSUITABLE FOR DEFENSE USE

STRATEGIC AND CRITICAL MATERIALS DOD APPROACHES TO REDUCED DEPENDENCE

	NEEDS ENGINEERING	R&D
CONSERVATION		
• MATERIAL SELECTION	✓	
• DESIGN APPROACHES	✓	
• PROCESSING METHODS		✓
• LIFE EXTENSION		✓
RECYCLING		
• SCRAP PROCESSING	✓	✓
• REPAIR OF COMPONENTS		✓
SUBSTITUTION		
• DIRECT SUBSTITUTION (AVAILABLE MATERIALS AND TECHNOLOGY)	✓	
• MODIFIED MATERIAL		✓
• NEW ADVANCED MATERIALS (COMPOSITES)		✓
• NEW ADVANCED PROCESSES (RST, POWDER)		✓

STRATEGIC AND CRITICAL MATERIALS R&D FOR REDUCED DEPENDENCE

AREA	APPROACH	EXAMPLE	PAYOFF
CONSERVATION	PROCESSING METHODS	NEAR NET SHAPE (HIP) PRECISION CASTING	UP TO 75% MATERIAL SAVING
	LIFE EXTENSION	RETIREMENT FOR CAUSE ON ENGINE COMPONENTS	UP TO 2 X LIFE
RECYCLING	SCRAP PROCESSING	PLASMA MELTING TITANIUM	UP TO 25% ADDITIONAL SCRAP RECOVERED
	REPAIR OF COMPONENTS	HIP CRACK HEALING	UP TO 2 X LIFE EXTENSION
SUBSTITUTION	MODIFIED MATERIALS	LOW CHROMIUM STAINLESS STEEL	REDUCED CONSUMPTION
		COBALT FREE SUPERALLOYS	REDUCED CONSUMPTION
	NEW ADVANCED MATERIALS	COMPOSITE MATERIALS (DOMESTIC SOURCES)	PERFORMANCE GAIN, WEIGHT SAVINGS, NON-STRATEGIC AND NON-CRITICAL MATERIALS
	NEW ADVANCED PROCESSES	RAPID SOLIDIFICATION TECH. AND POWDER METALLURGY	PERFORMANCE GAINS, WEIGHT SAVINGS, LESS MATERIAL

NEW PROGRAM TECHNOLOGIES TO REDUCE VULNERABILITY AND DEPENDENCY ON STRATEGIC/CRITICAL MATERIALS

- TITANIUM ALUMINIDES AND CERAMICS FOR TURBINE ENGINES
- TITANIUM CASTINGS, POWDER AND CAST COMPONENTS
- ISOTHERMAL AND SUPERPLASTIC FORMING/DIFUSION BONDING OF AIRFRAME AND ENGINE HARDWARE
- NET SHAPE POWDER METALLURGY

ENHANCED PROGRAMS TO ACCELERATE ADVANCED PROCESS OPTIONS

- CHIP RECYCLING
- SLUDGE RECLAMATION
- DIRECT SHAPE CASTING
- MULTI-PART FORGING

CONCLUSIONS

- DOD IS TAKING SIGNIFICANT STEPS TO REDUCE VULNERABILITY TO UNSTABLE FOREIGN SOURCES OF STRATEGIC/CRITICAL MATERIALS
- MATERIALS R&D
- MANTECH
- PRODUCTION OPTIONS
- SUBSTITUTION

The Office of Science and Technology Policy's View of Materials Policy Developments in the Reagan Administration*

I am pleased to represent John Marcum on this panel, and bring you up to date on what has transpired in this Administration from OSTP's viewpoint, relating to the 1980 National Materials and Minerals Policy Research and Development Act.

Historically speaking, the Reagan Administration early on recognized the need for an organizational structure to formulate its policy, and organized the Cabinet Council for Natural Resources and the Environment for this purpose. Interior Secretary Watt, Chairman of the Council, assigned the task of preparing a program plan to Perry Pendley, Interior's Deputy Assistant Secretary for Energy and Minerals. He organized a Strategic Minerals Policy Working Group made up of eight subworking groups and their work is reflected in the April 5th National Materials and Minerals Program Plan and Report to Congress. I participated in one of these groups on Research and Development. While there has been no end of both compliments and criticisms of this report, I would just like to say that getting such a document out of the Executive Branch was no easy task and Pendley deserves a lot of credit for the personal attention he gave to this matter.

This brings us up to the report itself and its implementation. Some of you here were present at Senator Schmitt's June 23rd oversight hearing on the Materials Policy Act and heard the President's Science Advisor Jay Keyworth testify for the first time on this issue. I'd like to quote parts of his testimony which are most relevant to the Administration's policy on the Government's role. He said: "We consider this year's program plan as only the beginning of a program of continuous high-level attention to the plight of this nation's materials and minerals situation. We fully understand the vital nature of materials to our industrial economy. Without competitive supplies of raw materials, our manufacturing endeavors will have difficulty in the global competition that exists today; and, without adequate advancements in the science and technology of materials, we lose our competitive edge for developing the products that must be constructed from these vital materials.

"This Administration shares the concern of addressing the need for high level coordination of the many materials and minerals activities within the Federal government. It is committed to dealing with the problem of increasing dependence of the United States and the free world upon foreign sources for strategic and critical materials. In his message to Congress, the President personally emphasized the critical role of minerals and materials to our economy, national defense, and standard of living. He also focused attention on the need for the Federal Government to concentrate its R&D effort in this area on long-term high-risk, and high potential payoff activities of wide generic application that are not being done by the private sector. The President expressed that this policy is responsive to America's need for measures to diminish minerals

*By Murray A. Schwartz, Division of Energy and Natural Resources, Office of Science and Technology Policy.

vulnerability by allowing private enterprise to expand our minerals and materials economy.

"Under the Plan, the Administration will continue its review and reform of excessively burdensome or unnecessary regulations and statutes which adversely affect the domestic minerals and materials industry.

"Materials stockpile policy is being effectively addressed. This Administration has undertaken the first stockpile purchase program in twenty years.

"In the broad area of R&D, the Administration has previously provided important new tax incentives in the Economic Recovery and Tax Act which should stimulate private sector R&D and is also reviewing patent policy with similar objectives in mind."

Keyworth continued: "My office, in concert with each department and agency, has been specifically tasked to direct senior officials in the applicable agencies in maintaining effective mechanisms for constructive R&D program coordination in implementing the national minerals and materials policy. All government funded R&D activities except those related to national security will concentrate on long-term, high-risk, high-potential payoff projects which have the best chance for wide generic application and improving the nation's economy."

Keyworth continued: "As you are aware, the President's April 5th Report to Congress reaffirmed the Committee on Materials (COMAT) under our Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) which I chair, for the purpose of coordinating federal minerals and materials R&D. I have asked John Marcum, my Assistant Director for Energy and Natural Resources, to chair the COMAT to ensure that it receives the required high level attention from the involved departments and agencies. COMAT members will include individuals knowledgeable in materials R&D as well as Assistant Secretarial-level people in their respective departments or agencies. It is our intention to involve both high-level policy makers and those program managers involved in materials and minerals R&D within the agencies to expedite policy implementation and to coordinate policy based on complete and factual information.

"COMAT's first order of business will be to carry out a complete inventory of agency projects to develop a data base on federal minerals and materials R&D for analysis or assessement and planning purposes. This in itself is not an easy task for our Federal bureaucracy has grown through the years, stretching out in many diverse directions. As previous COMAT efforts have shown, without this data base, analysis, assessment, and technical coordination cannot be accomplished effectively. With a good data base, we believe that it will be possible to ensure that our federal funds are being used as efficiently as possible and to redirect programs where necessary to better serve the national interest. Also, the individual agencies will become better informed on the total situation and be able to make their respective programs more effective. We will be particularly sensitive in this process to the need to emphasize promising materials research areas such as rapid solidification technology, substitution and recycling of materials, and fundamental materials science.

"With a clear Presidential Policy including specific COMAT responsibility, we have an excellent opportunity to effectively address an important R&D policy program need. I am confident that COMAT can succeed in this effort."

In closing, Keyworth stated: "I would like to assure you that the minerals and materials area and its problems will continue to receive attention at the highest levels of the Executive Branch. Answers to these problems are often complex in nature and always a number of solutions must be considered, one of which is research. My office, through COMAT, will give minerals and materials technology close attention and assure high-level consideration of these issues throughout the Executive Branch."

As mentioned in Keyworth's testimony, I have joined OSTP to be COMAT's Executive Secretary. The Committee had its first organizational meeting on June 30 and two Inventory Working Group meetings since then. Our next COMAT meeting is scheduled for July 28th. Obviously, we are on a fast track. Approximately 20 agencies which have minerals and materials R&D programs or concerns are involved, including OSTP, OMB, and the National Security Council from the Executive Office of the President. So, you can see, we have a forum of both policymakers and program managers that reach into the uppermost segments of the Executive Branch. We have a real opportunity to help our Government become more effective in matters relating to minerals and materials issues.

COMAT's new charter states, "COMAT shall identify key points of emphasis, as well as problems, related to national minerals and materials technology and availability needs and coordinate the development of long-range plans for an effective R&D program to meet clearly defined national objectives." This is a large order and to do this COMAT will reach out to the private sector whenever possible. Conferences such as this one should become ever more significant in bringing worthy matters to COMAT's attention.

Our Government has grown continuously and possibly excessively in the past 30 years. In this growth process, bureaucratic success has a tendency to be measured by size rather than effectiveness. The immensity of the Government's program has made it increasingly difficult to assess its effectiveness and efficiency. This is particularly so in the materials area as materials R&D is part of the programs of so many agencies and not always easily identifiable. Another way of looking at this problem is to consider the commonality of materials. In a broad sense, the same materials are being considered by a number of different agencies, possibly for different applications, but not necessarily so. This leads up to COMAT's first order of business, the preparation of an inventory of Federal materials R&D. We are planning to use this data base for assessment purposes for redirecting our current R&D program if necessary, to make it more effective and efficient. This will be COMAT's biggest challenge, as we are all well aware that problems will not be solved in the future by increased funding but by better management. We would like to see priorities established primarily on scientific and technical needs rather than on strictly economic considerations. To do this, it becomes more important than ever to be able to look at the total Federal materials R&D program rather than at its individual segments. How well we do this inventory, learning from the

experiences of COMAT's earlier 1976 inventory, will determine its usefulness.

In closing, I would like to emphasize that with the establishment of the Cabinet Council and COMAT, the Executive Branch now has an adequate organizational structure to address all problems in the minerals and materials area and ensure prompt implementation of the President's Materials and Minerals Policy Plan.

The National Materials and Minerals Program Plan: Prospects for Reducing Minerals Vulnerability*

The mineral industry has been pretty much ignored in Washington in the recent past. And, when past administrations did pay attention, the result was often less than favorable—more regulations, more land restrictions, more controls. Under the leadership of President Reagan and Secretary Watt, that has changed. There's a new spirit in Washington—a new spirit of cooperation and appreciation of the mineral industry and its importance to our Nation.

That new spirit is reflected in the new mineral policy statement—or, to use its proper name, the "National Materials and Minerals Program Plan"—that the President just recently submitted to Congress. The plan is a direct response to the mandate of the National Materials and Minerals Policy, Research and Development Act of 1980. It gives prominent recognition to the importance of minerals and the mining industry as fundamental supports for this Nation's economic and military security.

Despite this long overdue appreciation of the industry's role, the plan has not received universal approbation. Some disappointment has been expressed at the lack of specific measures in the plan to solve particular problems facing the industry.

We should keep in mind, however, that what we're talking about is a White House *policy* statement—not a legislative package. What it represents, aside from the President's concern for national security, is a public affirmation by the head of our government of the importance of minerals to this Nation. It signals clearly this Administration's commitment to reducing our country's dependence on unreliable foreign sources of minerals and to making our mineral industry a healthier, more viable sector of the economy.

It is the first such commitment from a President in nearly 30 years.

Let me summarize briefly what the new policy entails.

To quote from the President's statement, "It is the policy of this Administration to decrease America's mineral vulnerability by taking positive action that will promote our national security, help ensure a healthy and vigorous economy, create American jobs, and protect America's natural resources and environment."

The statement then outlines some of those positive actions:

First, it promises to continue the review of regulations affecting the mining industry, and to remove the unnecessary, burdensome, and unworkable ones as fast as possible. That promise has been honored from the moment that Ronald Reagan assumed the Presidency. Vice President George Bush heads the Administration's task

*By Robert C. Horton, Director, U.S. Bureau of Mines, Department of the Interior.

force on regulatory review and that review is moving rapidly ahead.

The opening of appropriate public lands to mineral exploration can lead to new discoveries and development. My boss, Jim Watt, has the lead in that area, and his agenda includes stepped up efforts to take inventory of the mineral resources of the public lands, to identify those areas currently off limits to the industry, and to make the process of gaining access to mineral reserves on Federal lands easier and faster. The new policy will also let the public and the industry have a larger voice in determining which areas should be developed first.

The policy calls for concentrating government minerals research on long-term, high-risk, high-potential-payoff projects with the best chance for wide generic application to materials problems. Specific projects, aimed at limited application, are best undertaken by the private sector, and the government will be encouraging such private research.

The policy calls for strengthening our ties with other Western countries, and encourages the exchange of minerals information between nations, between agencies, and between the public and private sectors.

And finally, it calls for increased attention to our strategic stockpile, with stepped up buying of those commodities for which we depend on interruptible foreign sources, and with a critical review of the quality of our current stocks.

But what is not in the statement is perhaps as important as what is. The use of stockpile purchases to subsidize depressed mineral prices is not promised. This band-aid approach has not helped in the past and it would not help today.

Special business concessions, specifically designed for the mineral industry, are not included. The general business problems of the mineral industry are problems shared with other industries, and were addressed in the Economic Recovery Tax Act of 1981.

And tariffs, import quotas, loan guarantees, and guaranteed purchase levels are not promised. This certainly should not surprise anyone, since the policy is wholly in keeping with statements the President has made in the past. It is wholly consistent with President Reagan's conviction that America's greatness stems from the individual realization of opportunity, not from government benevolence.

And it is wholly consistent with his philosophy that private enterprise can preserve and expand our mineral economy—if only given the *opportunity.*

The President's national minerals policy has been designed to provide that opportunity, through the establishment of a business and political climate conducive to the success of private enterprise. And what that policy represents is a commitment to work together in an area that is of critical importance to the Nation.

With its renewed emphasis on minerals, public lands, and strategic stockpiles, this Administration is bringing minerals back into consideration during land use planning. It's trying to weigh fairly the many competing demands on the Nation's resources, whether those demands are for environmental protection or for mineral development.

Let me give you just a few examples of what has already been accomplished by this Administration in an effort to balance the scales a little more evenly, and to reduce our minerals vulnerability:

Probably the most dramatic has to do with the withdrawal of public lands for single use purposes. Over the years, increasing amounts of federal lands have been closed to mineral exploration and development. The majority of the land restrictions have been the result of Congressional action or formal executive withdrawals. But there have also been some administrative actions that have resulted in "de facto" withdrawals. And this has happened during a time when our dependence on foreign sources for minerals has grown and the security of some foreign supplies has become more uncertain.

This Administration is looking closely at those withdrawals and at the impact they have on our Nation's mineral position, and we're doing something about the unnecessary withdrawals. In the first year of the Reagan Administration, more than 3.2 million acres of public lands were returned to multiple use, through 225 revocations by the Interior Department. And from January of this year to the present, several million additional acres have been freed for multiple use.

Along those same lines, Interior has increased coal leasing on Federal lands by 420 percent, from 8,465 acres in fiscal year 1980 to 43,857 acres in fiscal year 1981, and has issued the first competitive coal leases in a decade for new mines in Alabama, Utah, Colorado, and Wyoming.

The Interior Department is also taking a long, hard look at the regulations affecting the mining industry, and is revising many of the most harmful. During 1981, Interior revised or was in the process of revising 60 percent of the Office of Surface Mining's permanent program regulations. The revised regulations are being designed to move away from the "cookbook" approach to regulation, and instead, will set a general performance standard that industry can meet.

Recognizing the essential role played by the stockpile during a national emergency, President Reagan has ordered the first purchase program for the national defense stockpile in twenty years, starting in 1981 with purchases of approximately $100 million. And he requested an additional $106 million for purchases in fiscal year 1982, later limited by Congressional resolution to $57.6 million.

The President, last November, also directed the Federal Emergency Management Agency to procure 1.6 million tons of Jamaican-type metal-grade bauxite for the defense stockpile. This will be accomplished through a combination of direct cash purchases, exchange with excess materials from the stockpile, and by barter using agricultural commodities. It will be the first use of agricultural barter to acquire raw materials for the stockpile in almost 15 years.

The President is also working toward a Strategic Petroleum Reserve of 750 million barrels by 1989. In the first 12 weeks of its tenure, this Administration contracted for more oil for the strategic reserve than was contracted for during all of 1979 and 1980. And various methods are now being studied to accelerate even fur-

ther the acquisition schedule so as to give the United States added protection from foreign oil embargoes.

Through all of the measures that I've mentioned so far, this Administration has made a concerted effort to make sure that the mineral potential of public lands is considered at the highest levels of government—right along with environmental and wilderness concerns—during land use discussions.

To make sure that happens, one of President Reagan's earliest actions was to establish a Cabinet Council on Natural Resources and the Environment, chaired by Secretary Watt. Under the Council, working groups with representatives from many different Federal agencies were set up to deal with a variety of issues related to minerals. Those issues cut across all sorts of organization boundaries within the Federal government, and involve economic, technical, social, political, and military factors. For example, one group is examining in depth the potential for critical mineral supply bottlenecks that could impede defense mobilization and seriously affect vital manufacturing industries which serve our defense, transportation, computer, and auto industries. The goal is to put in place a strategic planning process to assure long-range adequacy of our mineral supplies.

And finally, this Administration has placed increased emphasis on mineral related research—especially research aimed at developing domestic sources of strategic and critical minerals. For example, in my agency, the Bureau of Mines, we restructured our budget, starting in fiscal year 1982, shifting about $8 million from environmentally-oriented research to research on strategic and critical minerals. Some of that research is aimed at developing the technology for producing minerals such as chromium, cobalt, manganese, and titanium from domestic resources. Other projects are designed to improve methods for recycling those minerals from scrap, increasing their recovery from waste-product streams at processing plants, or substituting other, more plentiful materials for them in some applications. And still other work is extending the useful lives of strategic and critical materials in a wide variety of uses—especially mining applications.

But no decisions about minerals—whether about which research to undertake, or which minerals to stockpile, or which lands to open or close to development—can be made wisely without adequate knowledge and data on our current mineral position. In an effort to provide that information, the Bureau of Mines collects data on mineral resources from all over the world. We analyze and interpret the data, and then make it available to government policy makers and to all interested segments of the public.

Speaking of data collection, I think many of you are aware that the Bureau of Mines gets most of its raw data straight from mineral producers and processors, who think enough of our statistical publications to fill out our canvass forms voluntarily—we have no mandatory authority to gather data for most minerals. Protecting the confidentiality of that individual company data has always been a concern of the Bureau. It's now a lot easier to protect it, thanks to the National Materials and Minerals Policy, Research and Development Act. That law contains a provision, effective upon

passage, that *forbids* general release of company data, except with the company's permission.

Because the need for mineral data is so vital, the Bureau has substantially strengthened its capacity for assessing international mineral supplies. In what we call our Minerals Availability System (MAS), we're building a computerized data base containing worldwide resource, engineering, and cost evaluations for major mineral properties around the world. The System will be priceless in helping us spot incipient supply disruptions and will let us pinpoint potential alternate sources of supply, should disruptions occur.

We've also established a new branch of mineral policy analysis, which is intended to provide a focal point within the Bureau for addressing mineral policy issues. The branch will also serve to link us with other agencies for joint analytical efforts.

For too long now, policy decisions affecting the mineral sector of our economy have been made with only bits and pieces of the relevant data and with little or no analysis to tie them together. The result sometimes has been that policy decisions were made with little real appreciation of the impact they would have on mineral availability.

That is a problem addressed in the President's mineral policy statement, with its emphasis on data collection and analysis. And it is a problem that we at the Bureau of Mines intend to remedy from now on.

In conclusion, I think it's fair to say that the President's national minerals policy, combined with what has already been accomplished in the minerals sector by this Administration, provides the basis for a far brighter future prospect for our minerals industry. By this I do not mean to imply that we've done everything that we can and will do, and I do not mean to imply that all the problems are solved. I know as well as you do that they are not.

What I do mean is that now the industry has an opportunity—an opportunity that has been badly lacking in years past.

The President's policy statement spells out his commitment to the mineral industry, and is designed to balance the scales between the many competing demands of this Nation's resources. It's not designed to *tip* the balance. When you get that kind of help from the government, it inevitably is accompanied by controls. The President's policy is designed to guarantee a fair chance, a chance to compete, and a chance to meet the challenge of a free economy. That means investment. The opportunity, increasingly, will be there. It will not be realized without risk, of course, but the President is firmly convinced that the industry is up to the challenge.

FEMA's Perspective on Stockpile Issues*

[Not submitted for publication.]

*By Paul Krueger, Assistant Associate Director, Federal Emergency Management Agency.

V. TASK FORCE REPORTS*

TASK FORCE ONE: RESEARCH AND DEVELOPMENT STRATEGIES FOR COPING WITH CRITICAL ISSUES RELATED TO ENGINEERING MATERIALS AND MINERALS**

Research and development in the areas of minerals and materials has provided this country with a wealth of extractive, process, and product technology that has contributed greatly to our present standard of living and to our defense capabilities. Until recently, R&D has not been substantially directed toward stabilizing our peacetime economy and reducing our strategic vulnerability. The main thrust has been in support of new applications and products. Now it is becoming recognized that R&D can be directed toward increasing supplies of minerals and materials and increasing the flexibility of materials usage.

President Reagan, in his April 5, 1982, National Materials and Minerals Program Plan and Report to Congress stated that the national materials policy recognizes:

—The critical role of minerals to our economy, national defense, and standard of living;

—The vast, unknown and untapped mineral wealth of America and the need to keep the public's land open to appropriate mineral exploration and development;

—The critical role of government in alerting the Nation to minerals issues and in ensuring that national decision-makers take into account the impact of their decisions on minerals policy; and

—The need for long-term, high potential payoff research activity of wide generic application to improve and augment domestically available materials.

The intent of the Program Plan appears to be to diminish minerals vulnerability by allowing private enterprise to preserve and expand our minerals and materials economy. Additionally, the plan clearly defines the government's responsibility for focusing government-financed R&D activities on long term, high risk objectives with the best chance for wide generic application to materials problems.

The questions that were dealt with by the Task Group on R&D included the following:

(1) Does President Reagan's National Materials and Minerals Program adequately respond to this country's needs for increased R&D in the materials and minerals area?

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*Chairman and Coordinator: Frank Richmond, Vice President, Specialty Steel Division, Universal-Cyclops.

**Co-Chairmen: William L. Swager, Manager, Materials Economics, Battelle Columbus Labs, Donald E. Thomas, Consultant, Westinghouse Electric Corp.

(2) Should the government fund materials research in an effort to reduce present or future vulnerability? If so, how should the goals of such research be determined? What role can industry and academe play in the selection of research objectives? In carrying out the program?

(3) How can the federal government better coordinate its own research projects on materials, non-fuel minerals, materials processing, substitution, recycling, etc.? Does it need to?

(4) What is the responsibility of industry in materials R&D?

(5) How can industry better communicate its materials needs to the government?

ISSUES AND CONCERNS

Adequacy of the Policy Statement

The President's statement of April 5, 1982, is generally viewed as an acceptable statement of policy when taken at face value. We concur with the position statement on long term R&D activities with high potential payoff of wide generic application, however, we have concerns for how the prioritization and continuity of R&D activities will be established and pursued.

Fundamental/Generic R&D

It was the judgment of the Task Group that there was an urgent need for more government encouragement and support of long range generic research directed at improved understanding of the fundamental aspects of minerals exploration, mining, extraction and processing, conservation and recycling. This expansion of the science base is required to enable the accelerated development of improved material systems and processes and the more efficient utilization of basic resources, both of which are essential to meeting foreign competition.

Continuity of Effort

In order to perform long term R&D, whether by the private sector or federally funded programs, it is necessary to establish a methodology to assure continuity and quality of the work. The policy statement re-establishes the Committee on Materials (COMAT), under the direction of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), for the coordination of Federal materials and minerals R&D activities. We view this structure as having some potential deficiencies for guaranteeing continuity of a long range R&D materials program. Our concerns are related to the political nature of FCCSET and are aggravated by recent history of shifting directions that have been taken in many high visibility, high-priority national technical efforts. We concur that COMAT has the potential for adequately coordinating the materials R&D requirements of the organizations that it represents, but we question whether COMAT can deal with establishing priorities for ensuring supplies of mineral and material. The mission-oriented agencies can agree to direct R&D toward assurance of future supplies only to the extent that it is consistent with their primary mission. More is needed. A respected, independent, and permanent Committee or Board composed of representatives of in-

dustry, the university community, and the government, is required to fulfill the President's Plan. It would identify research opportunties in all stages of the materials cycle, suggest priorities among these opportunities, and provide essential continuity.

Prioritization

In order to effectively define and coordinate policy, research, analysis and management tasks, a mechanism must be established by which R&D goals and associated tasks can be prioritized. This must include: input from industry (the primary users), government, scientific associations and the academic community. Objective means of evaluating the overall national and international importance of each mineral-specific or generic goal must be developed. Factors to be considered include:

—Importance to national security;
—Importance to industry and commerce;
—Extent to which the material can be replaced or conserved;
—National/international commodity supply/demand;
—Magnitude of known domestic reserves;
—Dependence on importation;
—Political stability of foreign import sources.

RECOMMENDATIONS

Two major recommendations have been formulated by the Task Group on Research and Development. These recommendations address questions of generic R&D and prioritization and continuity.

I. Fundamental/Generic R&D

It is recommended that research tasks be defined and prioritized in all phases of the materials cycle. In this sense, materials include mineral and renewable resource-derived commodities, such as natural rubber, but excludes food and energy fuels used as such. A balanced program will include activities in:

—Exploration/Cultivation (i.e. remote sensing);
—Mining/Harvesting (i.e. solution mining, comminution);
—Extraction and Processing (i.e. extractive metallurgy, purification, forming, etc.);
—Conservation (i.e. reduced in process-generated scrap, extended lifetimes, etc.);
—Recycling (i.e. reprocessing of scrap);
—Base technology (i.e. fundamental particle interactions, thermodynamics, corrosion mechanisms, biohydrometallurgy, etc.).

II. Continuity and Prioritization

The questions of priorities and continuity of research and development are critical and we believe that some permanent, independent, broadly representative advisory board should be established to identify the important areas of R&D for ensuring supplies of minerals and materials and encouraging their prudent use, to recommend priorities, and to maintain surveillance of progress.

TASK FORCE TWO: MANPOWER, EDUCATION, AND TRAINING*

I. EXECUTIVE SUMMARY: PROBLEMS AND RECOMMENDATIONS

1. Problems:
   A. Erosion in quality of university materials engineering education.
   B. Lack of materials technicians and skilled workers qualified and adaptable to meet the requirements of rapidly changing engineering and technology.
   C. Inadequate manpower data base to permit accurate projections on supply and demand of materials engineers, scientists, technicians and skilled workers to fulfill future national needs.
2. Recommendations:
   A. Education:
      1. Alleviate faculty shortage by increasing salary of junior faculty;
      2. Modernize university equipment and facilities for materials research and education;
      3. Increase stipend for U.S. materials science and engineering graduate students to attract high quality undergraduates;
      4. Modify undergraduate engineering curricula to meet needs of materials science community more effectively.
   B. Technicians and Skilled Workers:
      1. Improve high school academic education by increasing requirements for science, mathematics and engineering related subjects;
      2. Provide improved materials science and engineering education and training through greater use of two-year colleges, technical society training courses, inhouse training and continuing education.
   C. Manpower:
      1. The Federation of Materials Societies in cooperation with NSF, NMAB (NAS) and other organizations should develop an accurate and useful manpower data base for evaluating future demand requirements for materials related manpower.

PREAMBLE

Engineering education in the United States is in a state of crisis. The problem takes many dimensions: a national shortage of engineering faculty; overcrowding of undergraduate students in many schools and curricula which leads to reduced quality of instruction; reduction of graduate enrollments, especially amoung U.S. born students which portends an even greater future faculty shortage; an obsolescence of instructional and research equipment in engineering schools. Materials science and engineering (MSE) shares in this crisis, with corresponding implications for a deterioration in the quality of a significant portion of the professional manpower

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available for the materials field. There is some evidence that one cause of the decline in quality is due to the great increases in undergraduate student numbers. The quality of instruction and research in MSE is a severe problem for various reasons. For example, funding through normal channels has been inadequate to prevent obsolescence of equipment which is a requirement for excellence in education and high quality state-of-the-art research. To summarize, there is a real question about the future health and well-being of the educational enterprise which is charged with the responsibility of educating the nation's future MSE professional engineers and scientists.

Recognition of the essential role of materials manpower, education and training for attaining national objectives for materials was given in the National Materials and Minerals Policy Research and Development Act of 1980 (Public Law 96–479, October 21, 1980). The following is the relevant extract:

> SEC. 4. For the purpose of implementing the policies set forth . . . the congress declares that the President shall, through the Executive Office of the President, coordinate the responsible departments and agencies, and shall
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> * * * * * * *
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> (4) assess the need for and make recommendations concerning the availability and adequacy of supply of technically trained personnel necessary for materials, research, development, extraction, harvest and industrial practice, paying particular regard to the problem of attracting and maintaining high quality materials professionals in the federal service;

The President's response to the Materials and Minerals Policy Research and Development Act of 1980 discussed the tax incentives in the Economic Recovery and Tax Act that are intended to stimulate private materials research and development. Long-term, high-risk, high potential payoff research programs which show promise of wide generic application to materials problems and productivity are to be supported by government financed research. However, the issue of availability and adequacy of technically trained personnel necessary for materials research and development in the federal government is not mentioned in the President's statement, nor is the need to attract and retain "high quality materials professionals in the federal service." Moreover, the Administration's statement fails to address the crisis in engineering education or the education and training of engineering, scientific and technically skilled personnel. The growing plight of universities in attracting and retaining faculty, in conducting educational and research programs with old and aging equipment and in recruiting an adequate supply of graduate students are the major manifestations of this crisis. These factors are expected to produce an adverse impact on the ability of universities to furnish society with the quality and quantity of engineering and scientific personnel it will need, particularly in the area of materials.

DEFINITION OF PROBLEMS

I. Manpower

1. Problems Associated with Pre-College Science Education.—In recent years, there has been a substantial erosion of the science requirements and the degree of qualification of science teachers in American secondary schools. This is in dramatic contrast to the situation in other countries such as the U.S.S.R. and Japan. We believe that these deficiencies in science education pose a threat to both the pool of potential materials scientists and engineers as well as the pool of potential skilled supporting personnel and skilled labor for the materials industries.

2. Problems Associated with University-Trained Manpower.—Although there has been an explosive growth in the numbers of engineering undergraduate students in American colleges and universities, there has been a concurrent failure to attract many of the brightest students into graduate school for advanced training due to the lure of high industrial salaries for newly graduated B.S. level engineers. Thus, potential future materials researchers and faculty are lost. This is another example of "eating the seed corn." A related source of concern is the decline in the number of American-born graduate students; at present, about 45 percent of Ph. D. students in engineering schools are foreign students.

There is a continuing problem, especially at the undergraduate level, of attracting the best students into careers in materials science and engineering due to lack of public visibility of the profession, lack of glamour, etc. Furthermore, a substantial percentage of materials scientists and engineers trained at the graduate level are "converts" from other disciplines such as physics and chemistry, and thus the health and vigor of materials science are threatened by declines in the enrollments in other disciplines. The life blood of the materials profession is an adequate supply of graduate students with sufficient and continuous funding; these are by no means secure at the present time.

Another problem confronting the supply of trained manpower in the materials area is the phenomenon of "surge and oscillation." For example, in response to both market forces and an injection of about 10 million dollars from the federal government, American universities increased the annual supply of B.S.-level mining engineers from 260 in 1974 to 1000 in 1980; such rapid changes often lead from shortage to oversupply. (This illustrates the crucial need for an adequate data base and improved methods for projecting technical manpower needs.)

3. Problems in the Supply of Technicians and Other Skilled Technical Personnel.—The decline in scientific literacy and the quality of scientific education in secondary schools, together with a relatively small number of sources of training threatens the assurance of a reliable supply of skilled support personnel in the materials area. In addition to adequate numbers, the rapidly changing nature of technologies in materials technology requires a flexibility and adaptability in the nature of support personnel which is not likely to be obtained with the present system of training.

II. Educational Problems

1. Materials Science and Engineering Faculty Problems.—At present, there are about 10 percent vacancies in the faculties of American engineering schools, with a vacancy level of about 25 percent at the assistant professor level. These vacancies, particularly at the junior faculty level, persist for upwards of one year or longer, indicating a continuing, rather than a transient problem. The problem arises because of a combination of relatively low salaries, improved opportunities for satisfying research interests in industry and the increased difficulty in obtaining research funds, coupled with the large increase in undergraduate populations and teaching loads.

Another problem is posed by the population structure of university faculties. During the next five year period, substantial numbers of engineering faculty are expected to retire. This problem may be more severe for materials departments because of the large expansion in this area during the 1960's.

2. Equipment Obsolescence.—Materials science and engineering is an inherently equipment-intensive discipline and is thus very dependent on adequate supplies of scientific instruments. The problems in this area are of two types: equipment for undergraduate education and equipment for graduate training and research. Adequate undergraduate education requires equipment at least close to the state of the art; currently, many materials science and engineering departments are utilizing World War II vintage equipment for this purpose.

At the graduate and research level, the cost of equipment for "cutting edge" experiments, e.g., Scanning Transmission Electron Microscopes (STEMs), etc., are very expensive, so much so that the typical individual research grant is inadequate for proper instrumentation. Furthermore, funds for large equipment grants have become very scarce so that it is often impossible to put together adequate equipment packages necessary for faculty recruitment. Universities have not been able to solve the problem of modernization of equipment. This precludes many materials departments from moving into new fields such as materials processing, the materials side of microelectronics, etc. The proper maintenance of equipment at universities is also a dollar limited problem area.

3. Curriculum.—The curricula in MSE departments must be modified periodically to keep abreast of the rapid changes in materials science and engineering in order to assure that students acquire the necessary skills and competencies. There is a growing need to provide education and understanding to MSE students with regard to the relationship of technology, society and public policy. The majority of scientific and engineering professionals working in the materials field come from non-materials designated degree programs. Thus, it is desirable to provide students in non-materials designated degree programs with expanded formal education and training in materials science and engineering. MSE curricula should be formulated by educators but with input from the "user" community and practicing professionals.

III. Institutional Factors

Strong cooperation between industry, government and universities in research, education, training, exchange of personnel and use of equipment is very important. An example of a recent failure of that cooperation is provided by the demise of generic research cooperative programs, such as the Cooperative Automotive Research Program (CARP), which would have provided improved technology transfer and brought university talent in materials to bear on problems in the national interest. These programs have failed to materialize because government participation in the government-university-academic triad has been withdrawn.

Incentive for industrial equipment donation to universities, such as the tax recovery act, have not been effective. The economic recession has also retarded such efforts.

In-house industrial training programs for MSE personnel have proved very useful and effective but are not sufficiently widespread in industry.

RECOMMENDATIONS

1. We strongly endorse national efforts now underway and being considered to strengthen science and engineering related curricula at the secondary school level and efforts to increase the science and mathematics requirements for secondary school teaching certification.

2. The Federation of Materials Societies should work with the NSF, the National Academy of Sciences and other organizations to develop an up-to-date data base on materials science and engineering (MSE) manpower to aid in more accurate forecasts of manpower requirements. Improvements in the methodology of such forecasting are greatly needed.

3. Increased incentives should be provided for bright undergraduates to go on to graduate study in materials science and engineering. For example, stipends should be raised to about 50 percent of the prevailing industrial starting salary of B.S.-level engineers; e.g., NSF should raise their fellowships to these levels.

4. Added attention must be given to the adequate training of technicians, other support personnel and skilled workers. Support should be given to the development of adequate training programs in two-year colleges, to industrial in-house programs and to technical society programs leading to competence certificates.

5. The salaries of assistant professors in MSE departments must be increased in order to successfully compete with industry and retain such faculty. Universities have tried to do this by preferentially raising the salary of junior faculty, but it has not been enough. Adequate equipment for research must also be supplied to junior faculty in MSE to assure them of the opportunity for productive research careers.

6. Universities should be given first preference for surplus government equipment. For example, DOD and DOE equipment modernization programs at the weapons labs are resulting in the availability of 5–10-year-old equipment which would serve some of the immediate needs of MSE departments.

The provisions of the Tax-Recovery Act have not been successful in providing industrial gifts of equipment to universities; other approaches to this issue must be explored.

We encourage the use of block grants to MSE departments by NSF, DOE, etc. aimed at facilitating the acquisition of equipment. We support new instrumentation initiatives to provide an adequate influx of funds for an equipment modernization program in U.S. universities, the estimated cost of which is in the range of 1-2 billion dollars.

7. A more active participation of industry MSE professionals in the accreditation for MSE university programs is desirable.

In those portions of industry where in-house MSE training programs do not exist, universities should assist in developing program content and providing necessary support. In general, better coupling between engineering schools and industry with respect to industrial in-house training programs should be developed.

8. Increased attention should be paid to educating materials scientists and engineers in matters of the interaction between technology, society and public policy. MSE departments should make efforts to improve instruction in MSE for students in other engineering disciplines since the largest percentage of engineers working in MSE actually comes from non-materials designated degree programs.

9. The government should re-examine its position with respect to the need for generic industry-government-university cooperative research programs, which have been eliminated.

Task Force Three: Materials Availability*

As terms of reference, the following focus and rationale were accepted as general task force guideline objectives:

Focus: What additional steps should government, industry, and academe take to minimize the potential negative impact of heavy import reliance on critical materials?

Rationale: The U.S. depends to a high degree on raw material imports for civilian, industrial, and defense needs. This dependence can be reduced in a variety of ways including conservation, recycling, development of domestic resources, substitution, and stockpiling. At present, there is not clear agreement as to the effectiveness or potential effectiveness of any one of these approaches. This task force will consider the major alternatives for decreasing the potential negative impact of future short- or long-range changes in the availability of critical, imported materials.

Due to task force size and breadth of the subject matter the group was broken into three subgroups assigned the following subject areas:

Task Force Three (A)—Materials Availability: Raw Materials Supply and Production and Fabrication Capacity.

Task Force Three (B)—Materials Availability: Stockpiles.

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*Co-Chairmen: Robert Horton, Director, U.S. Bureau of Mines; Frank Elliott, Vice President, Teledyne Allvac.

Task Force Three (C)—Materials Availability: Development of Substitution Preparedness and Standby Conservation Measures for Critical and Strategic Materials.

Task Force Three (A): Raw Materials Supply and Production and Fabrication Capacity*

MINING AND PROCESSING

1. We view with alarm the accelerating decline of the metal processing industry and strongly recommend that environmental regulations be realistically structured and administered to allow operation of these essential industries.

2. The Government should encourage capital investment in mining and related processing industries, over and above present economic policies, to assure maintenance of our mineral industry base and to reverse the off-shore movement of these essential industries.

3. The Government must establish policies and procedures that will restore equity as regards the competition between domestic industries and subsidized foreign suppliers. While we firmly support the operation of free markets, free markets do not exist for many mineral commodities. The loss of mining, processing, and fabricating industries has serious national security implications for without those industries many stockpiled ores are useless and domestic ore deposits become unavailable for use in emergency situations.

POLICY COORDINATION

1. While we support the Cabinet Council on Natural Resources and the Environment we believe that continuity and centralization is required as regards the formulation, coordination and execution of National mineral policies. To that end we support the establishment of a council on Minerals and Materials as provided for in H.R. 4281.

ACCESS TO FEDERAL LANDS

1. To facilitate intelligent administration of Federal lands the Government should undertake a prompt accounting of all Federal lands to determine their location and identify any and all restrictions on the use of such lands.

2. A resource inventory of Federal lands should be initiated and carried to completion in a reasonable time frame. Resources shall include natural resources as well as all potential uses, public and private, for which the land could be reasonably utilized.

3. The continued discovery and development of our mineral resources is essential for the economic and strategic security of the United States. The Government must maintain orderly access to Federal lands for the purpose of mineral exploration along with a process to enable nomination and acquisition of areas for mining with suitable consideration for environmental concerns.

4. The Government must streamline regulations and permit processes regarding exploration and mining. Environmental concerns

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and consideration of alternate conflicting uses can be addressed in a less time consuming and more cost conscious manner than now requred.

DEFENSE PRODUCTION ACT

1. We support a five year extension of the Defense Production Act with adequate funding under Title III to provide market incentives for those minerals and materials for which we are presently highly import dependent and for which there exist substantial national security risks. In the past these incentives have been cost effective. Establishment and maintenance of domestic production of these essential security related minerals is in the national interest.

TASK FORCE THREE (B): STOCKPILES*

The National Defense Stockpile is a major contributor to our national security. Yet, stockpile actions over the years have resulted in much controversy. There is little disagreement over the need for and purpose of the stockpile. However, there is lack of public understanding about stockpile functions; there is a lack of industry input to the system; and there is a history of adverse effects from stockpile management decisions.

Many reports have identified specific problems and offered detailed recommendations on stockpile subjects such as the quality, form, and quantities of specific materials; the timing and methods of market transactions; the loss of domestic smelting and refining capability to convert current stockpile ores to usable form; and ways of providing industry input to stockpile management deliberations. Of primary concern is the accessibility of the stockpile to political and budgetary manipulation. We believe that many of these problems are due to deficiencies within the stockpile management system as established by existing enabling legislation.

We recommend that Congress conduct oversight hearings to evaluate the effectiveness of the current National Defense Stockpile management system, leading to revised legislation that will provide for:

a. Insulation of stockpile management decisions from short-term political and budgetary pressures.

b. An effective industry advisory committee structure.

c. Authority, within defined limits, for stockpile management to use transactions funds, barter transactions, or other mechanisms to achieve and maintain quantity and quality objectives.

We also recommend that:

d. Speedy attention be given to completion of plans to determine the quality level and form of stockpile materials vs. the current use requirements. (This has been a major unanswered question for several years, and we support the recent agency attempt to come to grips with this problem.)

e. Funding to reach stockpile goals be given a high priority.

f. Stockpile transactions be planned to minimize market impact.

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*Chairman: Frank Elliott, Vice President, Teledyne Allvac.

Other areas recommended for study include incentives for private stockpiling and an evaluation of the quality of the assumptions and techniques used in setting stockpile goals.

It was suggested that one method of maintaining stockpiles would be to require foreign suppliers to maintain some level of inventory in the U.S. (perhaps where vulnerability exists) as a condition of doing business here. No conclusion or recommendations were possible in the time frame available for discussion, and this idea is included here only as a matter of record.

Task Force Three (C): Development of Substitution Preparedness and Standby Conservation Measures for Critical and Strategic Materials*

1. RECYCLING

Specific questions presented concerning recycling were:

a. To what extent does recycling offer opportunities to decrease our long-range dependence on raw material imports?

b. What incentives exist, or can be developed, for increased recycling?

c. Is new technology needed to permit increased recycling?

d. Do existing product specifications restrict recycling by requiring that certain residuals be maintained at artificially low levels, simply because the actual effect of those residuals has not been defined?

The subject of recycling as it relates to materials availability was discussed thoroughly. The findings and conclusions on the subject were primarily positive.

Recycling does offer opportunity for this country to decrease its long-range dependence on strategic mineral imports. Recycling can be separated into two categories:

a. Primary recycling—where scrap generated in a manufacturing process is recycled directly back into the manufacturing cycle in an individual plant;

b. Secondary recycling—where a material is recycled after it has been in final product form. A good example is the aluminum beverage can.

There are basically *three* reasons for, or incentives, to institute recycling:

a. Profit motive—when it is economic to recycle and still maintain desired product quality;

b. Environmental compliance motive—when recycling enhances the ability to comply with regulations such as the Resource Conservation and Recovery Act;

c. Conservation motive—when it is necessary to conserve on materials where availability is restricted.

It was concluded that three primary disincentives to recycling are:

a. When recycling technology is unavailable;

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*Chairman: Charles Marvin, Vice President, The Refractories Institute.

b. When recycling is not economical. This often is the case because the technology has not been developed to make the recycling economical;

c. When there are no economies of scale problems of collection logistics. The individual quantities of recyclable material being generated at an individual site are too small to make primary recycling justifiable, and the logistics of collection to make recycling of the given material on a large scale feasible and economical have not been implemented.

It was concluded that:

The export of scrap *may* represent a drain on certain critical materials. Insufficient data was available to evaluate the export of scrap containing each mineral designated as critical.

The *government role* in recycling should be one of facilitating recycling in cases where shortages of critical materials may threaten the national security. This role is primarily one of continuing basic government research on recycling approaches, identifying existing recycling technologies, and formulating contingency recycling plans for strategic minerals in an emergency. The government should evaluate the impact of export of scrap containing critical materials.

Recommendations for recycling:

It is recommended that the federal government initiate the following actions with respect to the recycling of materials critical to the nation:

a. The government should initiate an activity to identify existing recycling technologies for most critical materials, e.g. Cr, Mn, Co, for use in emergency situations. This technical information and/or sources of information should be published and disseminated to industry.

b. The government should develop contingency plans for the logistics of collecting and utilizing recyclable critical materials, e.g. Cr, Mn, Ta, Cb, in a national emergency.

2. SUBSTITUTION

Specific questions presented concerning substitution were:

a. To what extent does "substitution" offer opportunities for reduced dependence on imports in a peacetime economy?

b. To what extent does "substitution" offer opportunities for reduced dependence on imports in a wartime economy?

c. What incentives are there for industry to develop substitutes?

d. Should such an effort be initiated and funded by the government?

The Task Group concluded that substitution of critical materials does offer opportunities for reduced dependence on imports in both peacetime and wartime situations.

Three basic incentives for substitution were identified:

a. Economic—the substitute reduces overall costs;

b. Regulation—Substitution is often forced by regulation, e.g. asbestos and lead. Often this is also economic, for substitution can be more economical than attempting to comply with the regulatory requirements while using the regulated material.

c. Conservation—Scarce materials are utilized only where it is absolutely necessary to accomplish the desired function.

It was also concluded that:

Substitution technologies for some critical materials in important end uses may not now exist.

The developing of substitution technologies should be a joint government/industry/academia responsibility and effort.

The government role should be defined as one of promoting the development of substitution technologies for the most critical materials for use in national emergency situations.

Recommendations for Substitution:

The following actions concerning substitution in the area of critical materials are recommended:

a. The government should review existing *substitution research programs* on identified critical materials (e.g. Cr, Mn, Ta, Cb) to assess their adequacy in assuring national security needs and identify significant gaps. The government should make recommendations on needed substitution research—both basic and applied;

b. The *Chromium Substitution Workshop* held in October 1982 should be a pilot project for a government information program on identifying existing substitution technologies for critical materials (e.g. Cr, Mn, Ta, Cb) in important end uses. The procedures and results of this workshop should be published, subjected to industry review, and refined; additional workshops should then be undertaken for other minerals to identify substitution technologies for use in a national emergency situation.

Task Force Four: Institutional and Industrial Factors*

On April 5, 1982, President Reagan sent to Congress the "National Materials and Minerals Program Plan and Report." The major thrust of this policy statement was to describe actions being undertaken by the Administration to strengthen the national economy, with special emphasis on the materials and minerals sector.

The Reagan Administration is to be commended for the minerals and materials actions outlined in the policy statement. We acknowledge the President's pointing out that, "These actions do not represent, nor should they be interpreted as, the total solution to America's minerals and materials problems."

The Task Force on Institutional and Industrial Factors considered *"institutional"* to mean generally the *interactions* between and within the various major materials-related organizational actors, i.e., government (Executive Branch and Congress), industry, organized labor, and academia. After examing the President's April 5 statement, the Task Force developed several recommendations concerning institutional and industrial barriers which exist in the materials policy area.

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*Co-Chairmen: James Arnold Miller, President, Interaction Systems Inc., S.L. Blum, Vice President, Northern Energy Corp.

RECOMMENDATION NO. 1: NATIONAL MATERIALS POLICY ACTION AREAS

Background

A national materials policy needs to have a *constituency* within the public to be effective—particularly a constituency among industry, organized labor, and academia. This constituency must be based as much as possible on *consensus* on the need for, and the requirements of, a national materials policy. Unfortunately, the existing "constituency" which is promoting a national materials policy is at best poorly organized, and inadequately informed regarding America's materials problems and possible solutions. In part, this situation is due to the fragmented nature of American society, the often competing interests of different American industrial sectors, and the newness of materials as an issue in terms of public policy consciousness. But the lack of a significant national materials constituency is due also to the traditional lack of government leadership on this issue, whether on the part of the Executive Branch or Congress. The President's April 5 statement is a major step in the right direction but much more needs to be done.

We believe that with strong, far-sighted, and results-oriented leadership the Executive Branch, with bipartisan active support of both houses of Congess, can undertake a national *campaign* to create a constituency to support the national materials policy. This effort should entail a *communications* program to relay facts to the public, and to promptly and effectively answer any questions about materials problems and what the United States is doing about them.

We further believe that if the Executive Branch continues to improve its interagency *coordination* of materials-related matters, then it will much more likely be able to communicate effectively with industry, organized labor, and academia on materials issues. *Cooperation* on materials issues between the Administration and the public constituency can and must be nurtured and expanded.

We believe that it will be easier to build the national constituency, and make the national materials policy more "comprehensive," if future policy statements and particularly action programs more fully deal with certain materials-related issue areas.

Recommendation: That the Administration take concrete actions concerning these important materials-related issue areas which were not fully treated in the President's policy statement of April 5, 1982: (a) international trade (e.g., concerning export and import policy); (b) alliance relationships (e.g., materials-related activities concerning America's allies, not just in research and development but also in such areas as stockpiling and joining the United States in securing raw materials shipping lanes); (c) foreign policy (the need for U.S. national materials policy to have a strong foreign policy component, and vice versa); (d) national security (the need for U.S. national security policy to move beyond considering uses of materials and insure that military planners and national intelligence organizations are adequately collecting information concerning and planning for international raw materials contingencies); (e) antitrust restraints (e.g., which restrict cooperation between and among industries on materials-related problems); (f) materials-related education and training (an area which especially needs inten-

sive attention); and, (g) providing organizational continuity in U.S. Government national materials policy planning. Concerning the latter point, the Task Force concluded that continuity in national materials policy planning is very important and should be maintained. The general feeling was that Presidential commitment and involvement is the key to an effective national materials policy.

RECOMMENDATION NO. 2; ANTITRUST POLICY

Background

Antitrust legislation in the United States grew out of noncompetitive practices and abuses of major corporations in the past century. The underlying philosophy of the antitrust legislation was to promote free competition. The major focus of this legislation was on competition within the United States. At the time the United States was a minerals exporter and a country rapidly becoming industrialized. This condition prevailed until World War II. Out of the wreckage of that war, the reconstruction of the modern industrial bases of Japan and Europe brought new competition to the United States, both for sources of raw materials and markets for U.S. products. This change can be illustrated by the reports of two materials studies, the "Paley Commission" report in 1952 and the National Commission on Materials Policy report in 1973. In 1952, the Paley Commission reported that the United States was the world's largest producer and consumer of raw materials. At that time the United States consumed 50 percent of the world's annual production of materials. Despite a continued growth of the U.S. economy, by 1973 U.S. consumption relative to the rest of the world declined to 30 percent. This trend is continuing today.

Today, the United States faces tough competition in a world market heavily penetrated by foreign industrial firms and combines, and, in some cases, government-owned enterprises. This competition is exacerbated by policies of our trading partners which often encourage rather than restrict growth, promote inter-firm cooperation, and subsidize export industries. Foreign firms often benefit from economies of scale and lower costs not possible in the United States. A stark example is the recent closure by Anaconda Copper of its smelting operation in Montana and the firm's shipping concentrates to Japan for smelting. One reason Japan is able to underprice U.S. smelters is because of a cooperative relationship among Japanese smelting firms—such a relationship is not possible in the United States.

Antitrust legislation was enacted by Congress and can only be changed by Act of Congress. Implementation and application of the law is the responsibility of the Executive Branch. Virtually all of American industry, with its millions of workers, is affected by antitrust restraints. A *cooperative* working relationship needs to be developed among the branches of government and the private sector (including management, labor, academia, and public interest groups) to develop the best facts, analysis and recommendations concerning the barriers to industrial development resulting from antitrust restraints.

Recommendation: That in light of the change in world trading patterns and economic conditions since the enactment of U.S. anti-

trust legislation, the Administration and the Congress, in close coordination with the private sector, review and act concerning the current impacts of this legislation on the health and competitive position of America's materials industries, and in particular concerning the restraints on cooperative research and development.

RECOMMENDATION NO. 3: INTERNATIONAL MATERIALS COOPERATION

Background

The existing institutional structure (i.e., the collection of organizations, associations, laws, rules and modes of behavior within which economic, political, military, social and religious activities take place) is the result of historical events and society's responses to them. As the environment in which these activities take place changes and presents different situations and problems, the institutional structure evolves to meet these challenges.

Today the economic, political, military and social position of the United States is less dominant than that which existed immediately following World War II. Thus it should not be surprising to find that the institutional structure which worked well in the past is no longer optimal. Given that planned changes in the existing international institutional structure are desirable, what goals should there be?

We suggest the objectives of fostering international *communication, coordination* and *continuity* as modest first steps in developing international *cooperation* in the materials field. Increased communication should be designed to develop better understanding and increase the flow of information within the international materials community. These flows should occur between elements of the private sector, between governments and between the public and private sectors.

Increased coordination in the fields of data collection and dissemination, research and development, manpower education and training, and policy formulation in such fields as supply disruption mitigation, stockpiles, supply diversification, access to resources and international investment should avoid duplicative efforts, provide for cross-fertilization of ideas and increase the effectiveness of resources devoted to material activities.

An important goal in considering alternative institutional arrangements is the provision of continuity. Continuity in the international materials institutional structure can be enhanced by developing and expanding national and international clearing-houses or focal points on materials matters. Working together, these centers will foster the development of materials expertise and "institutional memory."

By building on the existing international structure provided by such organizations as the United Nations, international trade associations, trade fairs, consumer associations and education exchanges, and by exploring the potential for the establishment of new structures related to material issues comparable to the International Energy Agency, the goals of increased international communication, coordination and continuity can be supported.

Recommendation: That the Administration, Congress, U.S. industry and academia go beyond present and planned activities con-

cerning international materials-related communication, coordination and continuity for the purpose of enhancing a permanent international materials institutional structure which promotes cooperation in the materials field.

Task Force Five: Materials as a Technological Force in Productivity*

SCOPE OF THE REPORT

The Task Force took as its scope the leverage that materials science and engineering exercise on productivity, i.e., the manufacture of effective and reliable products in an economically efficient manner. The Task Force chose to stress factors that fulfill three particular criteria:

(1) Those that are strongly materials-related,

(2) Those that are pervasive, that is important in a number of industrial sectors,

(3) Those that exercise high leverage on productivity.

TASK FORCE APPROACH

The Task Force elected to direct its attention to two principal aspects of productivity enhancement:

(1) Major technological opportunities that offer the greatest promise for important advances,

(2) Major policy issues that control attention to the technological opportunities.

The technological opportunities were reviewed by analyzing the various generic roles that materials play in the production process. These roles group naturally into those that increase the productivity of manufacturers through the production framework and into those that increase the productivity of users through innovative products. The productivity of manufacturers, in turn, was analyzed in two stages: first, the production of engineering materials, and, second, the conversion of these engineering materials into products.

Policy implications were then examined in light of the three institutions in our national structure where action might be anticipated: (1) industrial management, (2) the educational system, particularly the engineering educational system, and (3) government agencies, both federal and local.

This report is organized according to three types of leverage: (1) increased productivity through the production framework, (2) increased productivity through innovative products incorporating advanced materials, and (3) high priority policy vehicles for bringing about those increases in productivity.

INCREASED PRODUCTIVITY THROUGH THE PRODUCTION FRAMEWORK

Several areas of materials and processing science and technology stood out as holding exceptional promise for contributing to productivity. Significantly increased national attention to these areas is warranted. (These recommendations derive considerable urgency

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*Co-Chairmen: Arden Bement, Vice President—Technical Resources, TRW Inc.; Harris Burte, Director, Metals & Ceramics Div., AF Wright Aeronautical Labs.

from the observation that several of them are currently relatively unpopular and/or inactive in both the university and industrial research communities.) We shall deal later with this observation as an important policy issue; the promising areas of science and technology will be noted first.

The emergence of "computational plenty" and the possibility of integrated computer-aided design, manufacturing, and life management in the production and use of products makes demands on materials science and technology. It also offers enormous potential for productivity increases. Specific areas for attention include:

—Developing quantitative models to describe the unit operations and unit processes of producing materials and fabricating products (Included are efficient computational routines, open loop and closed loop algorithms, etc.),

—Developing the materials data base to feed into processing models for both workpiece materials and the tool materials (including a recognition that materials can be anisotropic or nonuniform and particularly that their structure and properties can, and often will, change during processing),

—Developing sensor technology that can operate in aggressive processing environments (preferably non-intrusively), and provide information about important factors such as the chemical and microstructural state of the workpiece material, its location and geometry, and the development of discrete defects.

These opportunities offer the attractive possibility of really optimizing design with production. Moreover, we may practice "total synthesis" of components or hardware such that the structure of the material and, therefore, its properties can be varied through a piece or product to optimize behavior as well as geometry and cost. We see the opportunity to provide tools to build in quality and reliability through all stages of design and manufacturing and to dispense with much final item inspection and rework. Coupled with models of the materials handling and distribution functions, we foresee the development and use of flexible manufacturing systems. This activity would also provide the core for an emerging discipline of "manufacturing science" through which it may be possible even to substitute "brains" for "manpower" in mature industries, and permit competition with lower wage rate economies. At the least, there should be significant activity to analyze the possibilities and to determine which mature industries might benefit from such an approach versus those where it would probably have little impact. Appropriate vectoring of R&D can follow. Additional related areas include:

—The development of life predictive models for materials and products under realistic use and environmental stresses,

—Inspection methodology to indicate reliably the state of the materials or products either continuously or at discrete intervals,

—Materials data bases for both life prediction and for quantitatively modelling the effectiveness of inspection as a function of hardware design,

—The development of rational maintenance strategies, such as "retirement for cause", and productive approaches for developing optimum combinations of "inspectability," "maintainability," etc., with initial design.

—The development of a sufficient data base for existing, substitute, and new materials in a format that would do the following: (1) facilitate their use with rapidly emerging computer-aided design (CAD), (2) reduce the cost and effort of bringing new or substitute materials into use, and (3) impose control over their manufacture and maintenance as discussed above. Data base sufficiency could assure the chain of confidence necessary to overcome the concern for a loss of reliability when making new materials selections that can contribute to productivity.

Another major area for increased R&D emphasis includes a broad variety of non-traditional approaches to producing materials, fabricating and finishing products, or even combining these within one processing approach. Examples include:

—Directed energy processing (such as laser machining, including materials behavior under, and in response to, the novel conditions involved),

—Plasma processing and other physical and chemical deposition approaches for creating coatings or special surface chemistries or structures, or for building up an entire product,

—Powder metallurgy (including the novel chemistries and structures that can be obtained by rapid solidification, gradients of properties within products, and non-conventional consolidation methods),

—Bioengineering approaches to materials processing (with the complete control of the "template" and thus of reproducibility and uniformity that this offers).

Additional areas that can make a significant contribution to productivity include:

—Advanced materials for tools or tooling (such as toughened ceramics; ceramic and intermetallic coatings; and rigid lightweight and dimensionally stable composites to extend part lifetimes and to permit improved control of dimensions or reproducibility of parts). R&D includes tribology, and innovative approaches to fabricating tools.

—Advanced joining processes for heavy sections (including autogenous welding).

Finally, the broad area of waste management warrants more attention than it has received. Emphasis should be placed on processes with reduced waste generation, methods to segregate or upgrade "waste" into useful input materials for a wide variety of products, and approaches for the degradation of hazardous wastes.

INCREASED PRODUCTIVITY THROUGH INNOVATIVE PRODUCTS INCORPORATING ADVANCED MATERIALS

Four generic technical areas were identified in which advanced materials are expected to lead to innovative products with unusually large advances in performance and thus in the productivity of the systems that use them.

A. Electro-optics and Electronics

The opportunities that optical communications present to expand current electronic technologies were noted. The seven orders of

magnitude advance in the transmission capability of optical fibers over the past 15 years will perhaps be augmented by the ability to optically process the information transmitted in place of current electronics information processing and storage.

B. Metastable Materials

Although non-equilibrium materials have long been employed, the range of opportunities for the establishment of special properties and structures has recently grown much broader. Through amorphous and microcrystalline materials, higher levels of hardness, corrosion resistance, and magnetic permeability may be obtained than in conventional systems.

C. Composites

The combination of particular properties through the union of disparate materials can lead to composites that can play special roles not previously possible; for example, combining strength with light weight, hardness with toughness, or toughness and corrosion resistance with dimensional stability. Polymer, metal and ceramic matrix materials are included.

D. Expanded Range of Commercial Polymers

It was noted that the number of commercially available polymers is a small fraction of those that are known and with which polymer scientists are familiar. Which of those not now commercially available could play a larger role in our economy?

HIGH PRIORITY POLICY VEHICLES FOR INCREASED PRODUCTIVITY

Policies and Practices

The Task Force recognized that technology is only one of a number of factors that contribute to improve productivity. Other factors dealing with policies and practices need to be considered. For example, focus on Japan's productivity achievements alone may be insufficient for leapfrogging that country in productivity and competitiveness. U.S. industry must learn how to use technology as a worldwide competitive force and to tap existing technologies throughout the world. Industry must also learn how to integrate long-range technology and market planning with strategic business planning. Moreover, compensation and reward systems in industry need to recognize not only short-term business performance, but also progress toward achieving long-term objectives, goals, and strategies.

Although the Task Force focused on materials technology issues, specific policy recommendations had to be broadened in some instances to cover science and technology in general. An effort was made to separate the issues and recommendations into two groups: those considered to have high-leverage potential for productivity improvement and those considered to be lower leverage, but nevertheless critical and pervasive. The recommendations are as follows:

High-Leverage Issues

1. Federal R&D policies should recognize needs for strengthening advanced applied research efforts in the materials technologies de-

scribed in this report, for channeling federal resources to universities engaged in training production-related engineering talent, and for providing continuity and stability for long-range basic research.

2. Engineering schools need to become better organized as "professional" schools. They need to establish upper-level curriculums in resource management, economics, public policy, and the management of complex systems. These curriculums need to be designed for both the initial training and the retraining of engineers preparing for management careers.

3. There is a need for more effective and frequent peer interaction of university faculty with their industrial counterparts through intern and exchange programs, joint research programs, and participation in industry's internal training programs. These initiatives are especially needed for introducing foreign-born faculty to the mainstream of U.S. industry.

4. Improvements in industry's status, reward, and value systems for engineers involved in manufacturing are needed to better motivate materials engineers to become more integrally coupled with production and production-control function.

Other Critical Issues

1. There is an urgent need to develop university faculty and programs in materials engineering for machine tool building and control, including robotics. Among the barriers that impede this development are the lack in these fields of peer-reviewed journals, the lack of leadership on the part of university administrators in granting tenured positions, and the lack of initiative in attracting top students.

2. There is an urgent need for raising standards and for improving the training of science and mathematics teachers in primary and secondary schools. Curriculums that provide applied science and mathematics training to non-college-bound students are especially needed.

3. Federal research agencies should make greater use of block grants and equipment grants to improve the productivity of research and development programs at universities. A critical review of the policies in these agencies that raise productivity barriers for both the conduct of research and development and for technology transfer is recommended.

4. The decline in federal support for the social and behavioral sciences is not in the best interest of improving the productivity of U.S. industry, since many of the current productivity issues are human factor issues. A review of this policy is recommended.

5. Universities need to use the discipline of strategic planning to rerationalize their legitimate interests and to reexamine their roles and missions in the light of persisting trends in national priorities and engineering talent requirements.

6. Training programs that motivate and prepare materials engineers to attain higher levels of decisionmaking and to perform more diverse roles in U.S. industry need to be given stronger support. Likewise, training programs that diffuse the knowledge of material properties and applications to engineers engaged in product design, product development, marketing, manufacturing, and procurement need to be promoted.

VI. APPENDICES

Appendix A: Conference Program

"Strategies for Coping With Critical Issues Related to Engineering Materials and Minerals"

The Seventh Biennial Conference on National Materials Policy, July 19–22, 1982

Monday, July 19, 1982

4:00 PM–9:00 PM — Registration and check-in—Lobby

7:00 PM — Opening Reception—Parlor A

Tuesday, July 20, 1982

7:00 AM — Breakfast—Family Dining Room

7:30 AM–8:30 AM — Registration and check-in—Lobby

8:30 AM–9:00 AM — Opening Session—Parlors B and C

Charge to Conference: Emanuel Horowitz, Vice President, Federation of Materials Societies

Significance of 1982 Conference: Allen G. Gray, Conference Chairman, Technical Director, American Society for Metals

9:00 AM–12 Noon — Session One—Parlors B and C

Chairman: John B. Wachtman, Jr., Center for Materials Science, National Bureau of Standards

"Key Elements Common to Critical Issues on Engineering Materials and Minerals"

Tutorial Lecture: Congressman Doug Walgren, Pennsylvania—An overview of where we stand and what progress has been made in dealing with materials issues

Tutorial Lecture: Hans Landsberg, "Resources for the Future"—Overview of elements of a national materials and minerals policy and strategy that could address effectively the problems and issues

9:00 AM–12 Noon — Panel—Parlors B and C

"Key Issues on Engineering Materials and Minerals Policy and How to Address Them"

Panel Moderator: William A. Owczarski, Chairman, Nonfuel Mineral Task Force, National Association of Manufacturers, Pratt & Whitney Aircraft Division

Industry Viewpoint:

- John W. Goth (supplier), Executive V.P. AMAX Inc.—presented by: David W. Delcour, AMAX Inc.
- James A. Ford (user), Director of Technical Engineered Products, Cabot Corp.
- Julius J. Harwood (user), Director, Materials Sciences, Ford Motor Co.

Government Viewpoint: Robert D. Wilson, Director, Office of Strategic Resources, U.S. Department of Commerce

The Seventh Biennial Conference on National Materials Policy, July 19–22, 1982—Continued

Academic Viewpoint: Paul Wynblatt, Carnegie-Mellon University

Special Presentation: J. B. Clark, Assistant Director, National Physical Research Laboratory, Council for Scientific and Industrial Research

"Strategic Resources of Southern Africa and Trends Towards Export in Alloy Form"

Colloquy from the floor: Questions and comments will be limited to "key issues" related to subject matter of this session

Summary by Panel Moderator: Will identify major problems/concerns

12 Noon — Luncheon—Cliffside Room

1:30 PM–5:00 — Session Two—Parlors B and C

Chairman: Stanley V. Margolin, Past President, Federation of Materials Societies, Arthur D. Little Co.

"Current Status of National Materials Policy—What Has Been Accomplished Thus Far"

Panel: *"Responses to the National Materials and Minerals Policy Research and Development Act of 1980"*

Panel Moderator: Stanley V. Margolin

Panelists:

Richard Donnelly, Director, Industrial Resources, Office of Under Secretary of Defense for Research and Engineering

Murray Schwartz, Division of Energy and Natural Resources, Office of Science and Technology Policy

Robert Horton, Director, Bureau of Mines

Paul K. Krueger, Assistant Associate Director, Federal Emergency Management Agency

Colloquy from the floor: Related to additional items which are the subject of this presentation.

Summary by Panel Chairman: Will identify accomplishments to date.

5:00 PM — Dinner—Cliffside Room

7:30 PM–9:00 PM — Session Three—Parlors B and C

Chairman: Frank M. Richmond, Vice President, Universal-Cyclops Specialty Steel Division

Organization of Task Forces Presentation by Task Force Chairmen

Wednesday, July 21, 1982

7:00 AM — Breakfast—Family Dining Room

8:30 AM–12 Noon — Session Four—Task Force Deliberations Chairman & Coordinator: Frank M. Richmond, V.P., Universal Cyclops, Specialty Steel Division

Task One: Research and Development—Jefferson

Co-Chairmen: William L. Swager, Battelle Memorial Institute, Donald E. Thomas, Westinghouse Electric Corp.

Task Two: Manpower, Education and Training—Shenandoah

Co-Chairmen: Emanuel Horowitz, Johns Hopkins University, S. Victor Radcliffe, National Forge Co.

8:30–12 Noon — *Task Three:* Materials Availability—Berkeley

Co-Chairmen: Robert Horton, U.S. Bureau of Mines, Frank Elliott, Teledyne Allvac

Task Four: Institutional and Industrial Factors—Morgan

Co-Chairmen: James A. Miller, Interactions Systems Inc., S. L. Blum, Northern Engineering Corp.

Task Five: Materials as a Technological Force in Productivity—Potomac

The Seventh Biennial Conference on National Materials Policy, July 19–22, 1982—Continued

	Co-Chairmen: Arden L. Bement, TRW, Inc., Harris L. Burte, Wright-Patterson Air Force Base
12 Noon	Luncheon—Cliffside Room
1:30 PM–4:30 PM	Session Five—Ad Hoc Meetings by Task Groups Drafting of Task Force Reports
	Chairman and Coordinator: Frank M. Richmond, Vice President, Universal-Cyclops Specialty Steel Division
	Task One—Jefferson
	Task Two—Shenandoah
	Task Three—Berkeley
	Task Four—Morgan
	Task Five—Potomac
4:30 PM–5:30 PM	Task Force Critique of Task Force Reports (Task Forces will remain in same rooms as listed above)
6:00 PM	Reception and Dinner—Parlors A, B, and C
	Observance of the 10th Anniversary of the Federation of Materials Societies
	Master of Ceremonies: N. E. Promisel, Consultant
	Speaker: Frederick Seitz, Rockefeller University
Thursday, July 22, 1982	
7:00 AM	Breakfast—Family Dining Room
9:00 AM–1:00 PM	Session Six—Parlor B and C
	Chairman: Edward Epremian, Consultant
	"What remains to be done? . . . Where do we go from here?"
	Task Force Reports
	Colloquy from the floor
1:00 PM	Luncheon—Cliffside Room
2:30 PM–4:00 PM	Session Seven—Parlors B and C
	Chairman: Edward Epremian, Consultant
	"What Remains to be done? . . . Where do we go from here?" (continuation)
	Wrapup discussion
	Conference Summary: Stanley V. Margolin, Past President Federation of Materials Societies
	Closing Comments: Allen G. Gray, General Chairman

Appendix B: Review of Banquet in Observance of the 10th Anniversary of the Federation of Materials Societies

The 10th Anniversary Banquet, held at Clifford Inn, was the major social event of this conference and served as a medium for reviewing the history of the Federation of Materials Societies (FMS) as well as its achievements during its first decade of operation. It also provided an opportune and appropriate occasion to present the first FMS Decennial Award as described below, and to hear an important address on a subject of deep interest to the Federation and the banquet audience. The dinner itself, of course, was not to be ignored and proved to be delightful.

The banquet program began with introductory remarks by Dr. Allen G. Gray, Conference Chairman, who commented on the conference perspective and introduced the distinguished guests and Federation and Conference Officers assembled at the head table.

Current Federation President Dr. Clifford H. Wells followed with a brief review of special events to mark the Decennial Year, FMS activities during the decade, and some plans for the future. To mark this year, first steps have been taken for a permanent materials exhibit at the Smithsonian National Museum of American History to illustrate the relationship and impact of materials on the social and cultural history of America and mankind. Several special FMS publications are planned: a history of FMS, a Who's Who in Materials, and a book of distinguished essays as an FMS Perspective on a Decade of Materials Science and Engineering. In addition, special seminars deal with critical materials issues as related to national materials policy and a follow-up of the 1980 National Materials and Minerals Policy, Research and Development Act.

Referring to the preceding ten years, Dr. Wells listed studies and contributions of FMS dealing with: many aspects of the above Act; a national materials information system; the energy crisis; the National Commission on Materials Policy in the early 1970s; cooperation with the congressional Office of Technology Assessment, the National Materials Advisory Board, the American Association of Engineering Societies (for which FMS is the materials representative), and the Congressional Research Service; and sessions with various groups in the legislative and executive branches of the Federal Government. Plans for the near future will extend these activities, increase interaction with industry as a whole, examine problems in the education and growth of materials scientists and engineers, and expand past international activities.

President Wells also presented to Dr. Nathan E. Promisel the First Decennial Award in recognition of conspicuous and distinguished service over a period of years to the multi-disciplinary field of materials science and engineering, and for the advancement of the goals of FMS.

Among his other remarks, Dr. Promisel, as a charter participant in the formation of the Federation, recalled the nucleation and growth of materials science and engineering as an integrated discipline upon which the Federation was based. He indicated that two dissociated developments in the 1940–1950 period were important catalysts. On the science side, major advances in the understanding of the behavior of materials at the atomic and sub-atomic levels showed a greater commonality of basic principles among differential materials categories than previously appreciated; and on the practical engineering side, there was growing emphasis, as in the aircraft industry, on the selection of the most efficient material to perform a given function, be it metallic, polymeric, or what-not. But as the concept of integrated, interdisciplinary and interacting materials science and engineering grew, it was increasingly apparent that there was no adequate mechanism to promote and take proper advantage of this concept, and no voice to speak, in a non-parochial and non-compartmentalized sense, for materials per se. It was to serve this overall purpose, efficiently and effectively, that FMS was created, with the full cooperation of the extant individual and specialized professional and technical societies.

The highlight address of the banquet was presented by Dr. Frederick Seitz, President Emeritus of the Rockefeller University and past president of the National Academy of Sciences. His theme was "The Role of Science in Development," particularly with respect to the less-developed countries. He pointed out, with illustrations, that "the culture of any society, not least the technical part, is partly borrowed and partly indigenous," with the borrowship often being absorbed as to become eventually indigenous. Science and technology have been consciously transferred from the more to the less developed countries often with economic assistance, motivated by conscious altruism, a desire to provide economic stability, a desire to strengthen and broaden mutually beneficial economic and cultural ties, and a desire to assist in minimizing biological hazards, both internally and externally to a country's borders. From a pragmatic point of view, it is necessary, in the United States, to be highly selective with respect to programs supported and mechanisms used, and to determine the likelihood of success. The extent and mode of monetary aid are clearly important. However, perhaps the most important goal, said Dr. Seitz, for interchange to promote science and technology is "to generate an essential mood of receptivity for the transfer and use of new technology within the partner nations," that is, the generation of "cultural receptivity." When this exists, exchange can be relatively easy and effective; otherwise, it can be very sluggish. Dr. Seitz gave specific and contrasting illustrations to substantiate these views. He reported on relevant international meetings convened to discuss transfer of science and technology for development, which have left him convinced that more intimate partnerships are required than can be provided by such broad international agencies as the United Nations. Universities can play an important role not only through professional education, but also by providing a home for those individuals devoted to selection of optimum areas and techniques for exchange. There is a new U.S. exchange program being developed through cooperation of the Agency for International Development

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and the National Academy of Sciences. In his conclusion, Dr. Seitz stated that "the cooperative transfer of science and technology—will be the more easy the higher the degree of appreciation of (its) benefits—and the greater the willingness to sacrifice for it."

Although Dr. Seitz's address terminated the banquet, much informal discussion of his stimulating remarks ensued thereafter, covering also other events of the evening.

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APPENDIX C: SUMMARY OF MATERIALS RELATED LEGISLATION IN THE 97TH CONGRESS[1]

Much of the materials related legislation introduced into the 97th Congress was an attempt to build upon the foundations set down by the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96-479). In principle, Public Law 96-479 called for the promotion of policies aimed at insuring an adequate and stable supply of materials necessary to maintain national security, economic well-being, and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources, conservation, and social needs.

Over 300 bills were introduced to respond to a perceived materials policy need. Some relate directly, others tangentially, since materials by definition cut across a wide range of societal issues and concerns. The bills discussed in this summary are grouped into five categories which reflect the breadth and diversity of materials policy issues: coordination of a national materials policy, the national defense stockpile, industrial revitalization, development and conservation of natural resources, and hazardous waste and safety issues.

COORDINATION OF A NATIONAL MATERIALS POLICY

In the 97th Congress, H.R. 4281 and H.R. 3364 were the two major bills (not enacted) that proposed the establishment of a comprehensive materials policy coordinating mechanism intended to achieve the goals of Public Law 96-479.

The Critical Materials Act of 1981 (H.R. 4281) would establish a Council on Critical Materials in the Executive Office of the President to provide for necessary coordination of critical materials policies among the various agencies and departments of the Federal Government. Additionally, the Council would insure adequate and continuing consultation with the private sector concerning critical materials, materials research and development, Federal materials policies, and related matters.

Similarly, the National Minerals Security Act of 1981 (H.R. 3364) would establish a Council on Minerals and Materials to monitor, evaluate, and coordinate Federal programs and activities to improve conditions affecting the mineral and materials needs and resources of the Nation. The bill includes provisions that provide for reviewing domestic mineral resources potential, strengthening materials and minerals information systems (both foreign and domes-

[1] By Lennard G. Kruger, Analyst in Science and Technology, Science Policy Research Division, Congressional Research Service.

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tic), and improving national capabilities for capital formation through regulatory reform and revision of existing tax laws.

Two other bills, also not enacted, were related to materials policy coordination. The National Strategic Materials and Minerals Assessment Act of 1982 (H.R. 7084) proposed to establish a national strategic materials and minerals coordination program.

Of greater focus was H.R. 2358, which would establish a Mineral Conservation Research and Development Commission within the National Science Foundation. This Commission would provide for the development of substitute materials, and would inventory such major nonfuel raw materials as: aluminum, bauxite, chromium, platinum group metals, iron ore, nickel, natural rubber, manganese, zinc, tin, titanium, cobalt, mercury, tungsten, lead, columbium, vanadium, fluorspar, and copper.

NATIONAL DEFENSE STOCKPILE

The National Defense Stockpile received more attention than any other primary facet of materials policy. Over 25 bills on this subject were introduced, and of these, two were enacted into public law. Title II, Subtitle A of the Omnibus Budget Reconciliation Act of 1981 (Public Law 97-35) provides for improvements in the management of the National Defense Stockpile, and authorizes the disposal of various materials from the stockpile. This includes the disposal (subject to certain restrictions) of the following amounts of silver: 46.537 million troy ounces as of October 1, 1981; 44.682 million troy ounces as of October 1, 1982; and 13.9 million troy ounces as of October 1, 1983.

Congress followed up with an amendment to the Defense Appropriations Act (Public Law 97-114) which prohibited the General Services Administration from selling silver from the National Defense Stockpile until July 1982, by which time the President was directed to reassess the desirability of resuming disposals of silver from the stockpile. [The Administration announced late in June 1982 that the sale of silver from the strategic stockpile has been indefinitely postponed].

Of the nonenacted bills relating to the stockpile, most either involved stockpile management, or disposal or acquisition of various materials for the National Defense Stockpile.

Stockpile management bills included proposals to: shift stockpile policy-making and management responsibilities to the Department of Defense (H.R. 7414); establish an independent commission to oversee and manage the National Defense Stockpile (H.R. 4266, S. 1338, S. 1982); provide that the National Defense Stockpile Transaction Fund shall be an off-budget activity (S. 2906); and to require the Director of the Federal Emergency Management Agency to report to Congress on critical and strategic materials availability questions as they relate to the National Defense Stockpile (S. 2943).

Numerous bills introduced into the 97th Congress focused on the acquisition and disposal of stockpile material. Some mandated specific quantities to be bought or sold. For example, H.R. 2603 would authorize appropriation of various sums for acquisition of materials for the stockpile, including $131 million for silver; while H.R. 2784

would authorize disposal of approximately 139.5 million troy ounces of silver.

Other bills would seek to: acquire critical materials for the stockpile using revenues from leases on the Outer Continental Shelf (H.R. 5063); sell excess stockpile material while authorizing $2.14 billion for acquiring needed critical materials (H.R. 2912, S. 906); use stockpile silver reserves to mint silver coins (H.R. 4965, S. 1822); guarantee the disposal of silver in a manner that minimizes market disruptions while providing maximum revenues to acquire other stockpile materials that are in short supply (H.R. 5037, S. 1823); direct GSA to acquire copper for the stockpile in accordance with specified provisions of the Strategic and Critical Materials Stockpiling Act (S. 2429); and to require that moneys received from the sale of stockpile materials be used to acquire strategic and critical materials (H.R. 4266).

INDUSTRIAL REVITALIZATION

Perhaps symptomatic of 97th Congress' concern with industrial revitalization was the rapid passage and enactment of the White House Conference on Productivity Act (Public Law 97-367), which will generate recommendations to stimulate the U.S. productivity improvement rate.

Many other bills introduced in the 97th Congress sought to revitalize the sagging domestic minerals and materials industry. A variety of approaches were proposed, all aimed at improving the industry's productivity and enhancing its competitiveness in world markets. These bills generally fall into the categories of: capital incentives, regulatory reform, and international trade policy.

Capital Incentives

The Defense Industrialization Base Revitalization Act (H.R. 5540), though not enacted, represented a comprehensive attempt to revive the domestic metals industries. The bill would amend the Defense Production Act of 1950 (DPA) to strengthen the domestic capability and capacity of the Nation's defense industrial base. Financial assistance would be extended to achieve modernization of small to medium sized industries involved in the manufacture or supply of national defense materials. Also, the bill would establish a program to train workers in skills demanded by the defense industries.

Several bills, dealing with the defense industry and related to materials, were passed by the 97th Congress. Public Law 97-47 extended the DPA for one year through September 30, 1982; Public Law 97-336 provides a six-month unfunded extension until March 30, 1983. Of special significance to the defense industry was the Department of Defense Authorization Act of 1982 (Public Law 97-86) which includes provisions authorizing five-year defense contracts, and an increase in the cancellation ceiling of multiyear procurement contracts from $5 million to $50 million.

Research and development received some legislative attention, with bills providing direct funding and tax incentives. The Small Business Innovation Research Act of 1981 (Public Law 97-219) amends the Small Business Act to require Federal agencies to es-

tablish small business innovation research programs. Two other bills (H.R. 4564, S. 1657), introduced but not enacted, would establish a uniform Federal system for management, protection, and utilization of the result of federally sponsored science and technology R&D.

In the realm of tax incentives, the Economic Recovery Tax Act of 1981 (97-34) stands out. Title II provides, in part, for a tax credit of 25 percent of the qualified research expenditures of a corporation for the taxable year over the base period research expenses. The bill also allows the 25 percent tax credit for 65 percent of all payments to universities to perform basic research. Numerous bills (H.R. 5332, H.R. 5844, H.R. 6023, H.R. 6484, H.R. 6723, S. 2256, S. 2474) have subsequently been introduced to modify various R&D provisions of Public Law 97-34.

Related to simulating R&D, the 97th Congress also directed some attention to the education and training of engineers and scientists. Bills addressed the shortage of science and engineering teachers (H.R. 4667, H.R. 6774, S. 2475, S. 2738), and dealt with deductions for donating scientific equipment to schools (H.R. 5573, S. 2281).

Of particular note was the National Engineering and Science Manpower Act of 1982 (H.R. 5254, H.R. 7130), which would create a Coordinating Council on Engineering and Scientific Manpower, and would provide funding for engineering and science manpower, modernization of instructional equipment, technician training, and precollege science and mathematics improvement.

Regulatory Reform

Regulatory reform was seen by many as a way to improve industrial productivity by easing some of the financial burdens imposed by government regulations. Two major bills, the Regulatory Procedure Act of 1981 (H.R. 746) and the Regulatory Reform Act (S. 1080) were introduced to require agencies to analyze and publish the costs and benefits of new rules, authorize Presidential supervision of these cost-benefit analyses, and provide for increased public participation in the rulemaking process.

While these bills dealt with the regulatory process in general, other bills focused on specific issues of regulatory concern. Public Law 97-23 amends the Clean Air Act to authorize the extension of compliance dates for owners or operators of stationary sources in the iron and steel producing industry. Authorization of the Clean Air Act had expired at the end of fiscal year 1981, and many bills were introduced to amend the Act (H.R. 2024, H.R. 2055, H.R. 2286, H.R. 3473, H.R. 5252, H.R. 5555). Particularly relevant to the metals industry was the introduction of S. 2477, which would loosen environmental constraints on primary nonferrous smelters.

Concerning safety regulations, there was some controversy involving the respective jurisdictions of the Mine Safety and Health Administration (MSHA) and the Occupational Safety and Health Administration (OSHA) in the mining industry. Public Law 97-72 transferred safety and health responsibilities for surface mining of stone, sand, gravel, clay, and colloidal phosphate from MSHA to OSHA. However, Congress subsequently passed Public Law 97-216, which returned these operations to MSHA.

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International Trade Policy

The foreign trade deficit of the United States was a matter of great concern in the 97th Congress, and measures were taken to remedy the situation. Accordingly, a comprehensive bill (S. 2094) was introduced that would strengthen the President's authority to retaliate against unfair foreign trading practices.

Many other bills, none enacted, were proposed to amend the tariff schedules. Of particular significance to the materials world were: H.R. 6439, which would increase tariff duties on imported steel mill products and iron ore if exceeding 15 percent of apparent steel supply; H.R. 6438 and H.R 2558, which would impose additional duties on copper and copper bearing ores; H.R. 660, which would delete tariffs for U.S. metals exported and then returned for additional processing; and H.R. 2479, which would extend until June 30, 1984 the existing suspension of duties on certain metal waste and scrap. More materials covered by proposed tariff schedule amendments include: rubber and plastics (S. 2859), textiles (H.R. 7118, S. 1565), and chemicals (H.R. 4555, H.R. 6867).

DEVELOPMENT AND CONSERVATION OF NATURAL RESOURCES

The current Administration has strongly emphasized greater natural resource development as a way to decrease the Nation's minerals vulnerability. Consequently, Congress initiated much legislation concerning public land use and ocean seabed mining. On the other hand, recycling and conservation received scant attention compared to past Congresses.

Public Land Use

Several bills sought to open up some public lands for minerals development, though none have been enacted. The National Minerals Security Act of 1981 (H.R. 3364) would open some public lands to development through a nomination process. The bill would also extend the deadline for mineral access to wilderness areas from 1983 to 1993.

Other bills dealt in various ways with the designation and eligibility of wilderness areas for fuel and nonfuel mineral leasing: H.R. 5603 contains provisions that would allow the President to open any wilderness area for development if an urgent national need for specific natural resources exists; H.R. 6542 would withdraw designated wilderness areas from oil and gas leasing, while allowing continued prospecting and mineral evaluation in wilderness areas; and H.R. 5282 would withdraw 62 million acres from mining and mineral leasing. Finally, the Public Land Reform Act of 1981 (H.R. 3655, S. 1245) would set up a mechanism to transfer Federal lands in the West back to the States.

Ocean Seabed Mining

The 97th Congress channeled considerable attention to ocean seabed mining, particularly as it relates to the Law of the Sea Treaty. Legislative activity featured: Public Law 97-416, which amends the Deep Seabed Hard Minerals Resources Act to authorize appropriations for fiscal year 1983, fiscal year 1984, and fiscal year 1985; bills (H.R. 7225, S. 2997) to create an Exclusive Economic

Zone out to 200 nautical miles from the coastline; and a series of resolutions expressing the sense of the Congress concerning the Law of the Sea Treaty (H. Con. Res. 271, 306, 360, 394, S. Con. Res. 74).

Recycling and Conservation

In view of the Administration's efforts to eliminate Federal involvement in recycling and resource recovery programs, legislative activity in this area was correspondingly limited. However, attempts were made to maintain some of the ongoing recycling programs through reauthorization of the Resource Conservation and Recovery Act of 1976. The reauthorization bill (H.R. 6307), though not enacted, would continue funding for resource recovery implementation programs, recycled oil programs, and the Commerce Department's Office of Recycled Materials.

Two other bills related to recycling and conservation, H.R. 2498 and S. 709, would prohibit the sale of metal beverage containers with detachable openings, and mandate a minimum refund value of five cents per container.

Recycling and Energy

In response to an Administration proposal to rescind funding for production of biomass fuels (authorized under Title II of the Energy Security Act, Public Law 96-294), Congress passed Public Law 97-12 which rescinded $724.5 million (58 percent of the total).

In a related matter, Congress also passed the Surplus Agricultural Commodities Disposal Act of 1982 (Public Law 97-358), which directs the Commodity Credit Corporation to contract for the processing of surplus commodities into liquid fuels and agricultural by-products.

Other bills, not enacted, would amend the Energy Security Act to: authorize the U.S. Synthetic Fuels Corporation to guarantee loans for synthetic fuel projects using biomass resources (H.R. 3057); provide financial assistance for biomass energy projects which use wood or wood wastes and residues as feedstock (H.R. 5508); and extend the financing authority of the U.S. Synthetic Fuels Corporation to district heating or cooling projects and municipal waste energy projects (H.R. 5833).

Additional bills, introduced but not enacted, which relate specifically to recycling solid waste into energy are: H.R. 493, which would direct the Secretary of Energy to construct and operate national demonstration facilities for the conversion of garbage into fuels; and H.R. 555, which would establish an accelerated research, development, and demonstration program for the recovery of energy from municipal waste.

HAZARDOUS MATERIALS AND SAFETY

Concerns raised in this area by the 97th Congress include disposal and management of nuclear waste and other hazardous wastes, transport of hazardous materials, and related health and safety issues.

Disposal of Nuclear Waste

A comprehensive nuclear waste bill (H.R. 3809) received much attention by the 97th Congress, and was enacted into public law as Public Law 97-425. The Nuclear Waste Policy Act of 1982 establishes a Federal program for the storage and disposal of spent fuel and high-level radioactive waste from civilian nuclear activities. Other bills which were related to nuclear waste repositories include: S. 1662, H.R. 5016, H.R. 6598, and H.R. 7187.

Disposal and Management of Non-Nuclear Wastes

The major bill in this area was H.R. 6307, the Resource Conservation and Recovery Act Reauthorization Act of 1982, which would amend the Solid Waste Disposal Act to extend through FY83 and FY84. The bill would reauthorize funding for State and local hazardous waste programs, and would direct the promulgation of various regulations and standards related to hazardous waste management, including a provision that no generator of hazardous waste of more than 100 kg per month shall be exempt from specified standards.

A specific hazardous waste issue which received some attention by the 97th Congress was the export of hazardous wastes. Accordingly, S. 622 was introduced to amend the Export Administration Act of 1979 and permit the export of hazardous waste from the United States only pursuant to a validated export license from the Secretary of Commerce.

Transportation of Hazardous Materials

Two bills, S. 906 and H.R. 3403, were introduced to amend the Hazardous Materials Transportation Act. The bills would provide assistance that enhances the ability of State and local governments to respond to and prevent transportation incidents involving hazardous materials.

Health and Safety

The Toxic Substances Control Act of 1976 was reauthorized by the 97th Congress via Public Law 97-129. In other health and safety related developments of interest to the materials community, H.R. 638 and H.R. 6159 were introduced to establish a mechanism for measuring health hazards versus practical benefits of any substances considered for regulation.

Some specific materials which raised health and safety concerns in the 97th Congress were: asbestos (H.R. 5224, S. 1643); uranium ore (H.R. 5735); and flammable fabrics (H.R. 529, H.R. 1556). None of these bills were enacted into law.

APPENDIX D: THE NATIONAL MATERIALS AND MINERALS POLICY, RESEARCH AND DEVELOPMENT ACT OF 1980 (PUBLIC LAW 96-479)

Public Law 96-479
96th Congress

An Act

To provide for a national policy for materials and to strengthen the materials research, development, production capability, and performance of the United States, and for other purposes.

Oct. 21, 1980
[H.R. 2748]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Materials and Minerals Policy, Research and Development Act of 1980".

National Materials and Minerals Policy, Research and Development Act of 1980.
30 USC 1601 note.

FINDINGS

SEC. 2. (a) The Congress finds that— 30 USC 1601.

(1) the availability of materials is essential for national security, economic well-being, and industrial production;

(2) the availability of materials is affected by the stability of foreign sources of essential industrial materials, instability of materials markets, international competition and demand for materials, the need for energy and materials conservation, and the enhancement of environmental quality;

(3) extraction, production, processing, use, recycling, and disposal of materials are closely linked with national concerns for energy and the environment;

(4) the United States is strongly interdependent with other nations through international trade in materials and other products;

(5) technological innovation and research and development are important factors which contribute to the availability and use of materials;

(6) the United States lacks a coherent national materials policy and a coordinated program to assure the availability of materials critical for national economic well-being, national defense, and industrial production, including interstate commerce and foreign trade; and

(7) notwithstanding the enactment of the Mining and Minerals Policy Act of 1970 (30 U.S.C. 21a), the United States does not have a coherent national materials and minerals policy.

"Materials."

(b) As used in this Act, the term "materials" means substances, including minerals, of current or potential use that will be needed to supply the industrial, military, and essential civilian needs of the United States in the production of goods or services, including those which are primarily imported or for which there is a prospect of shortages or uncertain supply, or which present opportunities in terms of new physical properties, use, recycling, disposal or substitution, with the exclusion of food and of energy fuels used as such.

DECLARATION OF POLICY

SEC. 3. The Congress declares that it is the continuing policy of the United States to promote an adequate and stable supply of materials 30 USC 1602.

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necessary to maintain national security, economic well-being and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs. The Congress further declares that implementation of this policy requires that the President shall, through the Executive Office of the President, coordinate the responsible departments and agencies to, among other measures—

(1) identify materials needs and assist in the pursuit of measures that would assure the availability of materials critical to commerce, the economy, and national security;

(2) establish a mechanism for the coordination and evaluation of Federal materials programs, including those involving research and development so as to complement related efforts by the private sector as well as other domestic and international agencies and organizations;

(3) establish a long-range assessment capability concerning materials demands, supply and needs, and provide for the policies and programs necessary to meet those needs;

(4) promote a vigorous, comprehensive, and coordinated program of materials research and development consistent with the policies and priorities set forth in the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.);

(5) promote cooperative research and development programs with other nations for the equitable and frugal use of materials and energy;

(6) promote and encourage private enterprise in the development of economically sound and stable domestic materials industries; and

(7) encourage Federal agencies to facilitate availability and development of domestic resources to meet critical materials needs.

IMPLEMENTATION OF POLICY

30 USC 1603.

SEC. 4. For the purpose of implementing the policies set forth in section 3 and the provisions of section 5 of this Act, the Congress declares that the President shall, through the Executive Office of the President, coordinate the responsible departments and agencies, and shall—

(1) direct that the responsible departments and agencies identify, assist, and make recommendations for carrying out appropriate policies and programs to ensure adequate, stable, and economical materials supplies essential to national security, economic well-being, and industrial production;

(2) support basic and applied research and development to provide for, among other objectives—

(A) advanced science and technology for the exploration, discovery, and recovery of nonfuel materials;

(B) enhanced methods or processes for the more efficient production and use of renewable and nonrenewable resources;

(C) improved methods for the extraction, processing, use, recovery, and recycling of materials which encourage the conservation of materials, energy, and the environment; and

(D) improved understanding of current and new materials performance, processing, substitution, and adaptability in engineering designs;

(3) provide for improved collection, analysis, and dissemination of scientific, technical and economic materials information and data from Federal, State, and local governments and other sources as appropriate;

(4) assess the need for and make recommendations concerning the availability and adequacy of supply of technically trained personnel necessary for materials research, development, extraction, harvest and industrial practice, paying particular regard to the problem of attracting and maintaining high quality materials professionals in the Federal service;

(5) establish early warning systems for materials supply problems;

(6) recommend to the Congress appropriate measures to promote industrial innovation in materials and materials technologies;

(7) encourage cooperative materials research and problem-solving by—

(A) private corporations performing the same or related activities in materials industries; and

(B) Federal and State institutions having shared interests or objectives;

(8) assess Federal policies which adversely or positively affect all stages of the materials cycle, from exploration to final product recycling and disposal including but not limited to, financial assistance and tax policies for recycled and virgin sources of materials and make recommendations for equalizing any existing imbalances, or removing any impediments, which may be created by the application of Federal law and regulations to the market for materials; and

(9) assess the opportunities for the United States to promote cooperative multilateral and bilateral agreements for materials development in foreign nations for the purpose of increasing the reliability of materials supplies to the Nation.

PROGRAM PLAN AND REPORT TO CONGRESS

SEC. 5. (a) Within 1 year after the date of enactment of this Act, the President shall submit to the Congress— 30 USC 1604.

(1) a program plan to implement such existing or prospective proposals and organizational structures within the executive branch as he finds necessary to carry out the provisions set forth in sections 3 and 4 of this Act. The plan shall include program and budget proposals and organizational structures providing for the following minimum elements:

(A) policy analysis and decision determination within the Executive Office of the President;

(B) continuing long-range analysis of materials use to meet national security, economic, industrial and social needs; the adequacy and stability of supplies; and the industrial and economic implications of supply shortages or disruptions;

(C) continuing private sector consultation in Federal materials programs; and

(D) interagency coordination at the level of the President's Cabinet;

(2) recommendations for the collection, analysis, and dissemination of information concerning domestic and international long-range materials demand, supply and needs, including con-

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sideration of the establishment of a separate materials information agency patterned after the Bureau of Labor Statistics; and

(3) recommendations for legislation and administrative initiatives necessary to reconcile policy conflicts and to establish programs and institutional structures necessary to achieve the goals of a national materials policy.

(b) In accordance with the provisions of the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.), the Director of the Office of Science and Technology Policy shall:

(1) through the Federal Coordinating Council for Science, Engineering, and Technology coordinate Federal materials research and development and related activities in accordance with the policies and objectives established in this Act;

(2) place special emphasis on the long-range assessment of national materials needs related to scientific and technological concerns and the research and development, Federal and private, necessary to meet those needs; and

(3) prepare an assessment of national materials needs related to scientific and technological changes over the next five years. Such assessment shall be revised on an annual basis. Where possible, the Director shall extend the assessment in 10- and 25-year increments over the whole expected lifetime of such needs and technologies.

(c) The Secretary of Commerce, in consultation with the Federal Emergency Management Administration, the Secretary of the Interior, the Secretary of Defense, the Director of the Central Intelligence Agency, and such other members of the Cabinet as may be appropriate shall—

(1) within 3 months after the date of enactment of this Act, identify and submit to the Congress a specific materials needs case related to national security, economic well-being and industrial production which will be the subject of the report required by paragraph (2) of this subsection;

(2) within 1 year after the date of enactment of this Act, submit to the Congress a report which assesses critical materials needs in the case identified in paragraph (1) of this subsection, and which recommends programs that would assist in meeting such needs, including an assessment of economic stockpiles; and

(3) continually thereafter identify and assess additional cases, as necessary, to ensure an adequate and stable supply of materials to meet national security, economic well-being and industrial production needs.

(d) The Secretary of Defense, together with such other members of the Cabinet as are deemed necessary by the President, shall prepare a report assessing critical materials needs related to national security and identifying the steps necessary to meet those needs. The report shall include an assessment of the Defense Production Act of 1950 (50 U.S.C. App. 2061 et seq.), and the Strategic and Critical Materials Stock Piling Act (50 U.S.C. App. 98 et seq.). Such report shall be made available to the Congress within 1 year after enactment of this Act and shall be revised periodically as deemed necessary.

(e) The Secretary of the Interior shall promptly initiate actions to—

(1) improve the capacity of the Bureau of Mines to assess international minerals supplies;

(2) increase the level of mining and metallurgical research by the Bureau of Mines in critical and strategic minerals; and

(3) improve the availability and analysis of mineral data in Federal land use decisionmaking.

A report summarizing actions required by this subsection shall be made available to the Congress within 1 year after the enactment of this Act.

(f) In furtherance of the policies of this Act, the Secretary of the Interior shall collect, evaluate, and analyze information concerning mineral occurrence, production, and use from industry, academia, and Federal and State agencies. Notwithstanding the provisions of section 552 of title 5, United States Code, data and information provided to the Department by persons or firms engaged in any phase of mineral or mineral-material production or large-scale consumption shall not be disclosed outside of the Department of the Interior in a nonaggregated form so as to disclose data and information supplied by a single person or firm, unless there is no objection to the disclosure of such data and information by the donor: *Provided, however,* That the Secretary may disclose nonaggregated data and information to Federal defense agencies, or to the Congress upon official request for appropriate purposes.

Nonaggregate data, disclosure.

THE MINING AND MINERALS POLICY ACT OF 1970

SEC. 6. Nothing in this Act shall be interpreted as changing in any manner or degree the provisions of and requirements of the Mining and Minerals Policy Act of 1970 (30 U.S.C. 21a). For the purposes of achieving the objectives set forth in section 3 of this Act, the Congress declares that the President shall direct (1) the Secretary of the Interior to act immediately within the Department's statutory authority to attain the goals contained in the Mining and Minerals Policy Act of 1970 (30 U.S.C. 21a) and (2) the Executive Office of the President to act immediately to promote the goals contained in the Mining and Minerals Policy Act of 1970 (30 U.S.C. 21a) among the various departments and agencies.

30 USC 1605.

SEC. 7. Section 1001(a) of title X of the Act of November 3, 1978 (Public Law 95-586), is revised to read as follows:

Geothermal resources, conveyance to Boise, Idaho.

"SEC. 1001. (a) The Congress hereby authorizes and directs that the rights to the geothermal resources, including minerals present in the geothermal fluid, presently vested in the United States of America in real property designated as Tract 37, located in sections 2 and 11, township 3 north, range 2 east, Boise meridian, Idaho, containing 4.13 acres more or less;

"Tract 38, located in sections 1, 2, 11, and 12, township 3 north, range 2 east, Boise meridian, Idaho, containing 449.16 acres more or less;

"Unofficial tract 39, located in section 2, township 3 north, range 2 east, Boise meridian, Idaho, described as follows: from the corner of sections 2, 3, 10 and 11, north 76 degrees 26 minutes 17 seconds, east, 1,705.44 feet, thence north 60 degrees 08 minutes east, 593.41 feet, thence north 25 degrees 28 minutes west, 911.46 feet to the southeast corner of tract 39 and point of beginning, thence north 25 degrees 28 minutes west, 660.0 feet, thence north 69 degrees 47 minutes west, 933.24 feet, thence south 26 degrees 24 minutes east, 544.50 feet, thence south 57 degrees 26 minutes east, 240.24 feet, thence north 64 degrees 32 minutes east, 795.30 feet and point of beginning, containing 14.644 acres more or less;

"Unofficial tract 40, located in section 11, township 3 north, range 2 east, Boise meridian, Idaho, described as follows: from the corner of sections 2, 3, 10, and 11, south 84 degrees 44 minutes east, 905.7 feet to the northwest corner of tract 40 and point of beginning, thence south

22 degrees 40 minutes east, 593.75 feet, thence north 84 degrees 45 minutes east, 940.20 feet, thence north 16 degrees 15 minutes west, 315.2 feet, thence north 87 degrees 45 minutes west, 516.6 feet, thence south 68 degrees 14 minutes west, 141.3 feet and point of beginning, containing 4.95 acres more or less;

"Unofficial tract 44, located in section 2, township 3 north, range 2 east, Boise meridian, Idaho, described as follows: from the corner of sections 2, 3, 10 and 11, north 76 degrees 26 minutes 17 seconds east, 1,705.44 feet to the southwest corner of tract 44 and point of beginning, thence north 60 degrees 08 minutes east, 593.41 feet, thence north 25 degrees 28 minutes west, 911.46 feet, thence south 64 degrees 32 minutes west, 795.30 feet, thence south 67 degrees 21 minutes east, 373.03 feet, thence north 58 degrees 18 minutes east, 264.53 feet, thence south 74 degrees 02 minutes east, 154.31 feet, thence south 14 degrees 50 minutes west, 585.02 feet, thence south 9 degrees 31 minutes east, 165.79 feet and point of beginning, containing 9.94 acres more or less; be transferred by the Secretary of the Interior in fee to the city of Boise upon payment by the city of Boise of the fair market value, as determined by the Secretary, of the rights conveyed.".

SEC. 8. Title X of the Act of November 3, 1978, is further amended by adding a new section 1003 to read as follows:

Boise District Office Site, geothermal resources utilization.

"SEC. 1003. The Secretary of the Interior, through the Bureau of Land Management, is authorized to utilize geothermal resources found under the parcel known as the Boise District Office Site, described as commencing at the southwest corner of the Old Fort Boise Military Reservation, thence north 70 degrees 0 minutes east, 1,448.2 feet; thence north 4 degrees 32 minutes east, 627 feet to the true point of beginning; thence the following courses and distances: south 87 degrees 8 minutes west, 696.5 feet; thence north 21 degrees 2 minutes west, 532 feet; thence south 69 degrees 4 minutes west, 21.9 feet; thence north 22 degrees 40 minutes west, 86.3 feet; thence north 84 degrees 50 minutes east, 993.6 feet; thence south 4 degrees 32 minutes west, 624.95 feet to the point of beginning; consisting of 11.53 acres, more or less, contained in section 11, township 3 north, range 2 east, Boise meridian, Idaho.".

Approved October 21, 1980.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 96-672 (Comm. on Science and Technology).
SENATE REPORTS: No. 96-897 (Comm. on Commerce, Science, and Transportation) and No. 96-937 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD:
Vol. 125 (1979): Dec. 3, 4, considered and passed House.
Vol. 126 (1980): Oct. 1, considered and passed Senate, amended.
Oct. 2, House concurred in Senate amendments.

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APPENDIX E: THE PRESIDENT'S NATIONAL MATERIALS AND MINERALS PROGRAM PLAN AND REPORT TO CONGRESS

To the Congress of the United States:

I am pleased to submit the National Materials and Minerals Program Plan and Report to Congress, pursuant to the National Materials and Minerals Policy, Research and Development Act of 1980.

This national minerals policy recognizes:

The critical role of minerals to our economy, national defense, and standard of living;

The vast, unknown and untapped mineral wealth of America and the need to keep the public's land open to appropriate mineral exploration and development;

The critical role of government in alerting the Nation to minerals issues and in ensuring that national decision-makers take into account the impact of their decisions on minerals policy; and,

The need for long-term, high potential payoff research activity of wide generic application to improve and augment domestically available materials.

This policy is responsive to America's need for measures to diminish minerals vulnerability by allowing private enterprise to preserve and expand our minerals and materials economy.

RONALD REAGAN.

THE WHITE HOUSE, *April 5, 1982.*

NATIONAL MATERIALS AND MINERALS PROGRAM PLAN AND REPORT TO CONGRESS

Introduction

During the 1980 campaign, I expressed to the American people my deep concern regarding the increasing dependence of the United States and the free world upon foreign sources for strategic and critical minerals. I raised concerns regarding the state of the materials stockpile as well as government policies which have inhibited and hindered the ability of Americans to produce and supply these vital resources. I established a Strategic Minerals Task Force, which subsequently reported to me, suggesting administrative and legislative actions to address these important questions.

On March 13, 1981, I called for the expenditure of $100 million for the first major additions to the stockpile in over twenty years. $78 million went to purchase cobalt, a material which was then at less than 50 percent of our stockpile goals. At that time I indicated that I would take further action regarding strategic minerals.

I hereby transmit to the Congress my recommendations and a report on the activities to be undertaken by this Administration to

reduce America's materials vulnerability. These actions do not represent, nor should they be interpreted as, the total solution to America's minerals and materials problems. Nor should all import dependence be interpreted as vulnerability. Rather, these steps will begin to focus the attention of the nation on those specific mineral availability and processing problems that are posed to our economy and our national security by dependence on insecure sources where useable substitutes are not readily available. These actions represent a serious concern and commitment, the first such Presidential commitment in nearly three decades.

On October 21, 1980, the National Materials and Minerals Policy, Research and Development Act of 1980 was signed into law. That Act mandated a report to the Congress regarding actions taken by the Administration to implement it. This report is presented in response to that mandate.

Statement of Policy

It is the policy of this Administration to decrease America's minerals vulnerability by taking positive action that will promote our national security, help ensure a healthy and vigorous economy, create American jobs, and protect America's natural resources and environment.

Land Availability

Large amounts of federal land—estimates vary from 40 percent to 68 percent—are now closed to mineral exploration and development at a time when the nation has become increasingly dependent on foreign sources for many strategically important minerals.

Although these minerals are important to our civilization, our standard of living, and our defense, less than three-tenths of one percent of the nation has *ever* been disturbed by mining. Much of our public land is highly mineralized, but large amounts of that land now lie off limits to exploration and development.

Therefore, this Administration will continue to inventory federal land to determine the mineral availability and potential of that land, while protecting the environment and preserving for future generations those natural resource areas set aside by law for special purposes. To achieve a proper balance between wilderness and mineral needs of the American people, the Administation will seek legislation to preserve wilderness lands, to release from continuing uncertainty non-wilderness lands for multiple use, to ensure the availability of information regarding the mineral potential of wilderness areas, and to permit a reexamination of national wilderness policy in the year 2000.

Because large amounts of federal land have been withdrawn from mineral entry by obsolete and unnecessary Executive actions, this Administration will solicit from the public recommendations on public land to be made available for exploration and development, and will focus immediate attention on those areas. In addition, this Administration will accelerate the review of lands withdrawn from mineral exploration and revoke obsolete withdrawal orders, will continue a rapid withdrawal review program for Alaska lands, and will open to mining those lands withdrawn from

operation of the General Mining Laws but which are open to operation of the leasing laws.

To ensure that minerals location is considered by the Congress in future Congressional withdrawals of lands, the Executive agencies will, when appropriate, prepare and present to the Congress strategic and critical minerals impact analyses as a part of this Administration's comments on proposed future withdrawals.

The Administration is also seeking to reduce our future dependence on potentially unstable foreign sources of minerals by eliminating barriers to the development of the mineral resources of the deep seabed.

Unfortunately, the current draft Law of the Sea Treaty would create a burdensome international regulatory regime that would in effect discourage, if not prevent, deep seabed mining. Therefore, as I announced on January 29, we are seeking major revisions in the draft treaty at the current United Nations Conference on the Law of the Sea, so that the draft treaty would encourage deep seabed mining and meet other basic U.S. national interests.

Minerals Data

We recognize the critical role that minerals and materials play in our highly industrial economy, and the unpredictability of international events affecting the reliability of minerals supply. This Administration will therefore continue to collect minerals data and use it in monitoring trends and events affecting supply and demand. We will consult with other nations to improve the exchange of minerals information, and will do the same between federal agencies and States, and between the public and private sectors.

Research and Development

The favorable tax incentives in the Economic Recovery and Tax Act stimulate private research and development to ensure the availability of the materials essential to the nation's economy and national defense. Any government-financed research and development activities will concentrate on long-term, high-risk, high potential payoff projects with the best chance for wide generic application to materials problems and increased productivity. Mission-specific programs of the Department of Defense are an exception to this policy. Existing federal programs are being assessed to ensure conformity to this policy.

Regulatory Reform

The Administration will continue its review and reform of excessively burdensome or unnecessary regulations and statutes which adversely affect the domestic minerals industry. A summary of efforts to date is included as Appendix A.

Stockpile Policy

The security of America's foreign sources of materials can no longer be ignored. The United States imports more than half of our total supplies of twenty strategic materials. This Administration has undertaken the first stockpile purchase program in twenty years. We endorse the policy that the stockpile should be sufficient

to meet military, industrial, and essential civilian needs in support of the national defense in a crisis.

To achieve this goal, the Administration will seek Congressional approval to sell the excess reserves of materials currently in the stockpile. We are seeking Congressional appropriations to acquire necessary stockpile materials. We will use exchange and barter to acquire additional stockpile materials when in the best interest of the country.

We will direct a panel of experts to review the quality of materials in the stockpile and recommend such actions as may be necessary to ensure the quality of the stockpile. Finally, this Administration will rely primarily upon purchases on the open market to build the Nation's stockpile necessary for the national defense and national security.

Cabinet Council on Natural Resources and Environment

Strategic and critical material issues concern many federal departments and agencies. During the course of the Cabinet review, approximately twenty governmental bodies were involved in various aspects of the issue. There is a clear need for coordinated and focused attention to ensure the full and complete implementation of a national materials policy and the capability of the United States to address and respond to materials problems, particularly where the national security is concerned.

The involvement of numerous federal agencies in the materials issue reflects both the breadth of the issue, not only in the government but in the economy, as well as the existence throughout government of statutorily assigned missions and responsibilities which relate to materials policy.

It is therefore the position of this Administration that national materials policy will be coordinated through the Cabinet Council on Natural Resources and Environment. This will ensure high level consideration of important materials policy issues on a timely basis with the capability of prompt action on such issues by the President. The Cabinet Council requires minimum administrative staff, relying for detailed analysis upon the various agencies and departments which have ultimate statutory responsibility for implementation.

LAND AVAILABILITY

Background

Federal lands, totaling some 734 million acres, represent a vast, largely undeveloped storehouse of resources that are important to the nation's welfare. Among the most significant of these resources are minerals, particularly those of strategic importance to economic and national defense goals. Increasing amounts of federal land have been closed to mineral exploration and development while dependence on foreign sources has grown and the security of supply from some areas has been questioned.

The use of federal lands has been restricted for a variety of reasons by various mechanisms over a number of years. The majority of such restrictions have been imposed by Congressional action or formal Executive withdrawals, but there are also segregations of

federal land arising from administrative actions that amount to "de facto" withdrawals.

In 1980, the Bureau of Land Management promulgated surface management regulations which prevent undue degradation of public lands by mining activities. These regulations, authorized by the Federal Land Policy and Management Act (FLPMA), (similar regulations for national forests were promulgated by the U.S. Forest Service in 1974) make many of these past "protective" withdrawals unnecessary.

Until passage of FLPMA, authorities and administrative responsibility for Executive withdrawals were not clear, and among the consequences were a welter of overlapping withdrawals, lack of any central record of withdrawn lands, and an accumulation of obsolete or otherwise unnecessary withdrawals. FLPMA required a review of certain withdrawals, to be completed by 1991, revoking those that are not ". . . consistent with the statutory objectives of the programs." All types of withdrawals for other agencies, and withdrawals from mining and mineral leasing for national forests and land administered by the Bureau of Land Management, are to be reviewed.

New mineral deposits will not be found unless the private sector looks for them. It is to the nation's advantage to encourage this search. Government has a responsibility as owner of most of our better mineral lands to minimize unnecessary restrictions that limit that search. Economic use of our natural resources allows decisions to be based on full information of all values that are involved. Preservation of wilderness areas, for example, is an important goal that must be balanced against others, such as the national security.

Issues and Actions

1. Under the terms of the Wilderness Act of 1964, significant federal acreage (about 13 percent of all withdrawn lands) will become permanently inaccessible for mineral exploration and development, subject to valid existing rights, on January 1, 1984. While wilderness land is now open to leasing, virtually no leasing has been permitted under the discretionary authority provided. In the 1964 Act, Congress clearly intended to permit exploration of wilderness areas in the time provided. However, because of past bureaucratic resistance and the uncertainty of obtaining permission to develop, exploration has not occurred, even though minable deposits are known to exist in some areas and there are significant chances for discovery in others.

The Administration will seek legislation to withdraw from mineral appropriation and leasing all wilderness and wilderness study areas pending Executive or Congressional action until the year 2000. The legislation will permit the continuation of energy and mineral exploration activities that ensure the protection of the land values. The legislation will permit development of wilderness lands during a period of national emergency, upon a finding by the President of urgent national need. Also, the Department of the Interior will report to the Congress every five years regarding the energy and mineral potential of wilderness and wilderness study areas and the resource opportunities foregone, permitting an in-

formed reexamination of national wilderness policy during the 106th Congress. The Administration will seek a limitation upon the period of time that public lands may be withheld as wilderness study areas, setting dates after which time, without Congressional action, those lands would revert to multiple use. 2. An unknown amount of federal land is removed from entry by obsolete or otherwise unnecessary withdrawals. The Federal Land Policy and Management Act allows fifteen years to review previous withdrawals. Additionally, an estimated 5.6 million acres of federal land are closed to mineral exploration by federal applications for withdrawal which pre-date the Federal Land Policy and Management Act. The law allows these segregations to remain in effect until 1991, while new applications can segregate lands for only two years.

Millions of acres of federal lands (from 10 to 60 million acres) are open to leasing but closed to operations under the Mining Law, which suggests that controlled mineral activity may not be inconsistent with the purpose of the withdrawals. When review is conducted, it may fail to focus on the highest priority lands, that is, those most likely to have important mineral deposits. Additionally, administrative processing of revocations is inefficient, and there is a general lack of current, accurate information on federal land status.

The Administration will issue an invitation to the public to nominate areas of high mineral interest and use those nominations to identify "Areas of Critical Mineral Potential" as an overlay of existing land use designation in selected areas for priority withdrawal review.

The Administration will take other steps to stimulate land availability:

—There will be an acceleration of withdrawal reviews now scheduled to be completed by the end of fiscal year 1991.

—All federal agencies will perfect pre-Federal Land Policy and Management Act withdrawal applications as soon as possible; segregation of those lands will then end, absent a withdrawal order.

—We will open to operation of the General Mining Laws those lands now withdrawn by Executive or Secretarial Order, but which are open to operation of the leasing laws; but Congressional and military withdrawals would not be affected.

—All federal agencies will inform promptly, and consult with, the Interior Secretary prior to any new withdrawal.

The Administration will issue "blanket" revocations for certain categories of withdrawals citing public land orders that withdrew such lands, thus saving administrative work-years and *Federal Register* publication costs while revoking an estimated 400 separate outdated withdrawals.

The Administration, in commenting on future land withdrawals, will, where appropriate, prepare and submit to Congress strategic and critical minerals impact statements to ensure informed Congressional decisionmaking. Additionally, in the annual report required by the Mining and Minerals Policy Act of 1970, the Administration will provide to the Congress a strategic and critical minerals estimate of the amount of federal land which is administratively withdrawn from operation of the General Mining Laws, and ask

Congress to consider carefully the potential impact on America's mineral needs of designating more lands for withdrawn status.

3. There has been a series of reports in recent years deploring the lack of current, accurate information regarding federal land status and, more particularly, the availability of that land for mineral exploration. While special surveys, such as those conducted by the Office of Technology Assessment, Bennethum and Lee, and the Department of the Interior, provide some understanding of land availability and thereby some policy guidance for land use decisions in both the Executive and Legislative Branches, that information quickly becomes outdated. Thus, if the specifics of land availability are to provide the background for land use decisions, there exists a need for a system revealing the degree of availability.

The Administration will examine the state and quality of federal land use data and the systems available for improving the inventorying and cataloging of the status of federal land.

MATERIALS RESEARCH AND DEVELOPMENT

Introduction

Mineral resources, the basis of materials supply, are vital to defense and to a healthy economy. The entire materials cycle is a fundamental component of economic production and technological innovation. Technological innovation has always played a major role in meeting the problems of materials supply.

It is generally agreed that the United States has recently been exhibiting a lowered rate of productivity growth, and that an increased pace of technological innovation is needed. In many cases America's ability to compete with other nations in the world marketplace has been reduced because productivity has lagged behind wages, which has also contributed to inflation. As a result, the domestic minerals industry is no longer as advanced in mineral processing technology as many of America's foreign competitors.

Government's Role

Since business enterprise is the primary engine of technological change, the driving force behind technological innovation through research and development is the expectation of a satisfactory return in invested capital. If there are circumstances, either real or perceived, which increase cost, increase the time to commercialization, increase risk or otherwise reduce the return on investment, innovation will be discouraged. Thus the first and perhaps most important requirement for materials research and development is the existence of a favorable business and political climate which encourages both the initiation of the innovative process (financing research and development activities) and the undertaking of steps leading to commercialization (applied research and development).

A critical element of materials research and development activities, and an area of traditional government support, is the basic research necessary to the development of a scientific data base. This requires close coordination between agency programs addressing supply problems and those addressing materials manufacture and performance.

In addition, government intervention in, and assistance of, technological development is appropriate only where market forces are incapable of acnieving clearly defined national objectives. Thus government's attention regarding research and development activity should focus on long-term, high-risk potentially high-payoff technology that has the best chance for wide generic application.

To fulfill this role, the Administration will:

(1) create a business and political climate which will encourage private sector research and development;

(2) stimulate constructive coordination between industry and government in the area of technological innovation; and,

(3) focus and direct other government financed research and development activities on long-term, high-risk technology with the best chance for wide generic application to materials problems.

Regulatory Reform

As part of its effort to eliminate excessive and unnecessary regulations, the Administration will initiate an inquiry into federal regulatory policies that discourage private materials research and development activities.

Government-Industry Coordination

The Administration will, through the Office of Science and Technology Policy in concert with each department and agency with a significant materials research and development program, direct senior officials to maintain or create effective mechanisms for constructive coordination of mineral and materials research and development. This will include both basic research and current government programs of materials substitution research.

International Research and Development

The Administration will formally establish contacts with the European Communities and other free world countries for exchange of information on materials research and development activities.

IDCA Trade and Development Program

The Trade and Development Program (TDP) of the International Development Cooperation Agency (IDCA) is giving new emphasis to strategic minerals and metal-related development activities, in accordance with its legislative mandate. This will broaden opportunities for the U.S. private sector to participate in the development and diversification of foreign sources of supply of strategic and critical materials.

Intragovernmental Coordination

The Administration reaffirms the Committee on Materials (COMAT), under the direction of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) for the coordination of federal materials and minerals research and development activities, directing:

(1) Assistant Secretary-level representation from the departments and agencies concerned with minerals and materials;

(2) placement within COMAT of the Department of Defense Material Availability Steering Committee and the Interagency Materials Group;

(3) establishment of a Working Panel within COMAT to coordinate federal research and development on essential materials;

(4) establishment of a formal mechanism within COMAT for information exchange between agency materials research and development program managers; and,

(5) policy resolution of materials research and development questions will be provided through the Cabinet Council on Natural Resources and Environment.

MINERALS AND MATERIALS DATA COLLECTION

Introduction

Increasing U.S. reliance upon foreign sources for minerals, especially those vital to a modern defense system, the unpredictability of events that could affect the reliability of mineral supplies, and the expanding role of governments in determining the flow of minerals in international trade, require that policy makers have access to adequate information and analytical systems. While a number of federal agencies have long acquired, maintained and analyzed such data, the coverage, quality and reliability of foreign data, and the inadequate coordination of domestic data, have limited its usefulness.

The importance of mineral information has been consistently identified by every major mineral policy study commissioned by the Federal Government in the last thirty years. These studies and others have also urged better analytical capability to improve the integration of mineral concerns into the policy process.

Worldwide, it is generally agreed that the statistical reporting of minerals information by the U.S. Government is unsurpassed. Nonetheless, the complexities of other national goals which may conflict with future domestic productive capacity require improvements in data collection and analytic support. Similarly, the complexities of problems that can affect the flow of minerals in international trade, an essential element of U.S. supply, require a better understanding of the data and the impacts of policy options.

Mineral information and analysis can provide guidance on policies affecting the strategic stockpile, land use, tax and tariff, trade, investment, research and development, environmental protection, and other aspects of domestic and foreign policies.

Foreign Minerals Data and Analysis

The Administration will strengthen the Regional Resource Officer (RRO) program. The Department of the Interior will establish a formal minerals training program for all State Department personnel assigned to RRO positions, with emphasis on mining and minerals processing, marketing arrangements, and minerals policies.

The Administration will initiate discussions designed to improve the exchange of policy-oriented minerals information among market economy countries, to encourage the exchange of information on mineral investment problems, to improve the consistency of

statistical reporting, and to consult on issues relating to selected strategic minerals.

Domestic Minerals Data and Analysis

The role of the Federal Government in collecting and interpreting minerals data is recognized. While there has been some debate on whether too much or not enough data is being reported, industry has consistently urged full reporting of quantitative supply/demand data. As owner of one-third of the nation's lands, as purchaser and seller of raw materials for stockpile programs, and as law-maker affecting trade, tax, investment and environmental policies, the government has a major impact on all levels of exploration and development as well as on the overall health of the mining industry.

The Administration will seek increased and improved cooperation from the private sector in responding to minerals and materials date requests.

The fragmentation of minerals/material data among many agencies of the Federal Govermnment may inhibit location, access, and exchange of data necessary for analysis and decisionmaking. The Administration will examine the United States Government's minerals and materials data system, ensuring the full participation of all affected departments and agencies. The review will:

(1) identify possible data gaps, duplications, inconsistencies, and redundancies;

(2) ascertain the adequacy of minerals and materials analysis;

(3) explore the benefits and costs of a National Minerals Information Center within the Federal Government as a central repository for material and mineral reports and information;

(4) develop a means of providing adequate protection for proprietary and classified data; and,

(5) develop a mechanism for regular briefings regarding minerals problems to the Cabinet Council on Natural Resources and Environment.

STRATEGIC AND CRITICAL MATERIALS STOCKPILE—OVERVIEW

Introduction

The United States must implement materials and minerals policy programs to ensure that America's capacity to field and sustain fighting forces in the event of war or national emergency is not curtailed by a shortage of critical raw materials. To ensure that capability, this Administration is initiating a major interdepartmental effort to improve the nation's preparedness for national mobilization.

This review will address, among other issues, potential national security impacts of shortages of strategic and critical materials. This comprehensive approach will lead to the most efficient use of national resources in the event of a national crisis, including protracted conflicts and will be coordinated at the highest levels of the Administration to ensure the vigorous pursuit of all essential elements to restore a strong and lasting foundation for national security. This comprehensive approach to revitalizing our nation's mo-

bilization capability represents the most concerted high-level effort in the past twenty-five years. Preparedness in the area of materials and minerals availability is an important part of this effort.

Emergency Mobilization Preparedness Board

The people, government and economy of the nation must be prepared to work in concert to respond rapidly and effectively to meet national needs in the event of major peacetime and wartime emergencies.

President Reagan, to ensure this capability, established the Emergency Mobilization Preparedness Board (EMPB) on December 17, 1981.

The EMPB consists of the representatives of 23 key federal departments, agencies, and executive offices at the Deputy or Under Secretary level, normally meeting quarterly. The Chairman of the Board is the Assistant to the President for National Security Affairs.

The Board is tasked to develop overall policy and a plan of action that will immediately improve the nation's preparedness capabilities. As an additional task, the Board is responsible for monitoring federal agency implementation of these actions.

The Board has authority to resolve mobilization preparedness issues within the framework of current Administration policy.

The Board will perform the following functions:

(1) Formulation of recommendations concerning policy for emergency mobilization preparedness.

(2) Development of policy guidance documents for working groups and agencies to implement approved policies and plans of action.

(3) Resolution of mobilization preparedness issues within the framework of current Administration policy.

National Defense and Critical Materials

To fulfill our basic national security objectives, the United States must be prepared to marshal the military and industrial resources to sustain an adequate war-fighting capability. An integral part of this effort is an enhanced industrial mobilization capability to sustain and resupply our military forces through protracted conflict. We must assure the responsiveness and staying power of the industrial base.

A crucial aspect of any industrial mobilization capability is a secure, reliable, and sufficient supply of critical raw and processed materials. The United States and its allies are heavily reliant on imports of certain critical raw and processed materials. Thus, a long-term supply interruption could have serious consequences for United States and allied security by disrupting capabilities to produce military and essential civilian goods either in a declared national emergency or wartime mobilization.

Statutory Authority

As a result of the national defense and security requirement for a secure and reliable supply of critical raw materials, the Congress has provided the President with comprehensive legislative authorities to meet these defense and national security needs, including

the Strategic and Critical Materials Stock Piling Act (SPA), as amended, and the Defense Production Act (DPA) of 1950, as amended. The SPA authorizes the National Defense Stockpile of strategic and critical materials. Title I of the DPA authorizes the use of priorities in fulfilling contracts for goods and services, and controlled allocation of critical materials, when necessary to meet the needs of national defense. Title III of the DPA authorizes the use of a variety of incentives to expand production capacity and supply to meet national defense needs.

DEFENSE PRODUCTION ACT

The priorities and allocation program which implements the authorities of Title I of the Defense Production Act has been a key tool for mobilizing industrial resources in support of current military programs or expanded defense requirements in an emergency period since 1950. It is used to schedule production to assure timely delivery today and is capable of adapting to future materials shortages or cut-offs. Historically, the system has been tested by shortages of such materials as cobalt, copper, nickel, steel, and titanium, resulting from strikes, war, natural disasters, international politics, and economic conditions. It can, however, only apportion materials within the United States.

Key Elements of the Defense Materials System and Defense Priorities System (DMS/DPS)

The DMS/DPS serves a dual purpose: it provides the means for exercising the priority and allocation authorities of the President for the purpose of promoting the national defense or maximizing domestic energy supplies; and it provides a system which can be promptly expanded to direct the industrial sector of the economy to meet the exigencies of any emergency. The DMS/DPS is a flexible system which can be promptly adapted to special problems, particularly with respect to critical materials. Set-asides, specified minimum order quantities, and specified order lead times are effective tools to assure the equitable distribution of rated orders among all producers and suppliers, and assure timely delivery to defense programs. This assurance allows more effective handling of commercial business by providing producers with information as to the limits of their rated obligations. Other instruments, such as special priorities assistance, also can be effective in assuring timely delivery of materials in tight supply.

Action

The Administration is committed to increased effectiveness of this system through better understanding by government and industry of the principles and advantages of the system. The Department of Defense will continue to improve its educational program extending through the major commands to the acquisition staffs, including contract administration, and its defense contractors. The Department of Commerce (Office of Industrial Resource Administration) in cooperation with Defense, will coordinate with industry, and has already held 48 DMS/DPS training sessions during this Administration.

The Administration will improve the priorities and allocations system by simplifying the regulations. Toward this end, the Department of Commerce in June 1981, published in the *Federal Register* a proposed revision of the Defense Priorities and Allocations System (DPAS) Regulation.

THE NATIONAL DEFENSE STOCKPILE

Introduction

The Strategic and Critical Material Stock Piling Act states the stockpile is ". . . to decrease and preclude, when possible, a dangerous and costly dependence by the United States upon foreign sources for supplies of (strategic and critical) materials in times of national emergency." The Act further provides that the stockpile ". . . should be sufficient to sustain the United States for a period of not less than 3 years in the event of a national emergency . . ." and ". . . is to serve the interest of national defense only and is not to be used for economic or budgetary purposes."

Stockpile goals are established by matching the requirements of military, essential civilian and basic industrial sectors in support of national defense for a three-year national emergency to an assumed level of secure supply of critical materials. The resultant shortfall determines the stockpile goal as of any given year. Figure 1 illustrates the current stockpile inventory as compared with 1980 goals. It is apparent that restructuring of the stockpile inventory is necessary because many of the materials in the stockpile are either in deficit of their goal or in excess of their goal, and some are possibly technically deficient since they were acquired as long ago as the 1950's.

To fill the 1980 goals at March 1981 prices would require purchase of additional materials valued at approximately $12.5 billion. The stockpile inventory currently contains $7.64 billion of needed materials. Excess materials are valued at approximately $4.92 billion for a total stockpile value of $12.56 billion.

As shown in figure 2, the 61 family groups and individual materials in the stockpile can be divided into two categories:

(1) 24 groups and individual materials with inventory equal to or greater than the goals (39 percent).

(2) 37 groups and individual materials with inventory less than the goal. Of these, the goals for 24 are less than 50 percent filled (61 percent).

Planning

Each year, an Annual Materials Plan (AMP) is established representing a major effort by several agencies under the direction of the Federal Emergency Management Agency to develop a list of materials for stockpile acquisition or disposal. National security requirements are balanced against market constraints and fund availability.

Recent Action

On March 13, 1981, President Reagan ordered the first major stockpile acquisition in twenty years. In fiscal year 1981, the Congress provided $100 million for acquisition, and the President re-

quested an additional $106 million for fiscal year 1982, which is currently limited by resolution to $57.6 million. At Appendix B is a detailed listing of the current status of the stockpile, material-by-material, including the estimated current market cost for filling the stockpile to 1980 goals, and potential receipts from selling excess commodities.

The Administration will streamline the AMP planning process by providing for:

(1) five-year planning guidance to form the basis for GSA acquisitions and disposals; and,

(2) a fiscal year plan that matches annual budget ceilings, market conditions, immediate strategic requirements, and GSA purchase activities. In addition, GSA will chair a study group to determine whether there are inventory management deficiencies that can be corrected by measures such as rotation of stock and upgrading of storage sites.

Further Action

1. Stockpile Policy

The Administration continues to endorse the nation's stockpile policy. The key elements of the policy are:

That the stockpile should be sufficient to meet the military, industrial, and essential civilian needs for the first three years of a war. (Required by statute.)

That the war scenario shall be consistent with the scenarios being developed by the Emergency Mobilization Preparedness Board chartered by Executive Memorandum dated December 17, 1981.

That goals reflect detailed assumptions regarding changes in a wartime civil economy, wartime foreign trade patterns, shipping losses, wartime political and economic stability of foreign nations, and alternate foreign and domestic production levels for stockpile materials. (Assumptions were derived by a major interagency effort and endorsed by President Ford on August 6, 1976, and reaffirmed by Presidential letter dated October 10, 1977.)

Pace of Acquisitions

Whatever level of funding is chosen through the appropriation process, the decision should ensure long range planning to facilitate acquisition storage site selection, site preparation, and personnel strategies.

The Administration will expeditiously dispose of those stockpiled materials held in excess of goals and acquire additional materials through the appropriations process. Additional materials will be acquired in keeping with budgetary constraints and other national priorities.

This program demonstrates a serious commitment by this Administration to enhance significantly the national security.

Two additional mechanisms, exchange and barter, are authorized for acquiring material for the stockpile. The Administration will seek cases where these are more efficient and effective mechanisms than open market transactions.

As part of the Administration's plan to use all appropriate and cost-effective means to fill stockpile deficiencies, President Reagan directed FEMA, acting through GSA and USDA, on November 24, 1981, to procure 1.6 million tons of Jamaican type metal grade bauxite for the Defense Stockpile during fiscal year 1982. This large and cost-effective acquisition program will be accomplished through a combination of direct cash purchase and exchange with excess materials from our stockpile by GSA, and barter using agricultural commodities with USDA. Agricultural barter to acquire needed raw materials will thus be used for the first time in almost fifteen years. This barter arrangement follows from the Congressional mandate contained in Section 6 of the Stockpiling Act of 1979.

Status of Stockpile Inventory—Quality and Form

In the past, questions have been raised about the quality of the stockpiled materials. In addition, the form in which material is held may not be ideal for current industrial use. Recently steps were intitiated to address the adequacy of the quality and the appropriate mix of alternative forms of existing materials.

Since the material in the stockpile is old, a careful review of the quality and form of stockpiled materials is in order. Therefore, this Administration will establish a panel, with appropriate private sector input, to review the extent of material deficiencies and to recommend remedial action, if needed. It should be noted that stockpile materials from past sales have been used with only minor difficulties.

Stockpile Alternatives

The stockpile is designed to meet the needs of a three-year national emergency for materials not readily available from domestic sources. Consequently, each annual ton of new domestic production reduces stockpile requirements by three tons for as long as productive capacity is available.

The United States has a wide variety of mineral and material resources. There is significant U.S. production of such materials as aluminum metal, beryllium, copper, iodine, mercury, molybdenum, titanium, and lead. The United States also has potentially significant but undeveloped resources of non-bauxitic aluminum, cobalt, guayule (natural rubber), platinum, nickel, and titanium bearing materials. For a variety of reasons, the private sector has not found it profitable to invest in domestic production of certain critical materials. Several disincentives to investment will be significantly reduced by many of this Administration's initiatives regarding economic recovery, unnecessary regulations, streamlining procurement practices, and federal land availability.

Title III of the Defense Production Act authorizes federal loans at below market rates of interest, loan guarantees, price supports, and guaranteed purchase levels. While this authority was used successfully during the 1950s, it has not been used recently except for the appropriation of $3 billion in fiscal year 1980 for the development of a synfuels capability.

This Administration will rely primarly on the strategic stockpile as the primary means of providing for national defense objectives.

However, analysis is now ongoing to determine whether circumstances exist under which the use of Defense Production Act incentives would be more cost-effective than stockpile purchases.

International Minerals Policy Coordination

Most industrial free market countries are more heavily dependent upon imported minerals than the United States (the two principal exceptions are Canada and Australia), but the United States is the only industrial nation with a significant stockpile of minerals and other critical materials for national defense. Other nations have investigated economic or strategic stockpiling of certain materials, but few programs have been carried out. Therefore, this Administration will initiate and conduct periodic and *ad hoc* consultation and coordination of the strategic and security policy aspects of non-fuel minerals and associated processing capabililties among industrial nations which are consumers of key materials.

We recognize our interest in policies which would create and maintain international markets for critical materials and the need of producing and consuming countries to cooperate to their mutual trade benefit.

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Land Access Regulations:
Department of Commerce

Regulations	Need for Reform	Status*
NOAA: Deep Seabed Mining Regulations	Action accomplished. Promulgation of regulations removes uncertainty as to conditions for exploration.	Final rules for exploration licenses issued 9/15/81

Safety and Health Regulations:
Department of Labor

MSHA: Mine Safety and Health Act of 1977	The statute imposes some overly burdensome requirements. It is generally believed that statutory changes are necessary to provide relief.	Legislative alternatives are under review
MSHA: Metal/Nonmetal Safety and Health Standards (30 CFR Parts 55-57)	Many of the standards are ambiguous, outdated, duplicative, and disorganized.	Review in process; public conferences are being held
MSHA: Noise Standards (30 CFR Sections 57.5-50 and 70.500)	Noise standard needs to be revised to consider feasible and more effective alternatives to the present regulations.	Under review
MSHA: Civil Penalty Assessment Procedures (30 CFR Part 100)	More reasonable civil penalty regulations need to be developed.	Hearings have been held; still in rule making process
OSHA: Lead Standards	Means of abatement very costly. Review to focus on cost/effective approaches.	ANPRM published 4/81
OSHA: Asbestos Standards	Reviewing scientific evidence on asbestos.	Under review

*Unless specifically noted, review is conducted by the designated agencies, at their initiative, subject to procedures described in Executive Order 12291.

Regulations	Need for Reform	Status*
BLM: Recordation of Unpatented Claims (43 CFR Part 3830)	Present regulations are claimed to impose excessive filing costs and harsh penalties for noncompliance.	Under review
BLM: Preference Right Lease Application (43 Subpart 3521.1-1 et seq.)	Present requirements for preference right leases may delay development of valuable minerals.	Under review
BLM: Public Land and Resources: Planning, Programming and Budgeting (43 CFR Part 1600)	Existing regulations may impede day-to-day administration of public lands and, consequently, mineral development.	Proposed rules published 11/81
BLM: Areas of Critical Environmental Concern	Identification and designation of ACECs may be broader and more inclusive than envisioned under FLPMA, unnecessarily limiting access to resources.	Guidance being reconsidered
FWS: Endangered Species Act Rules (50 CFR Chs. I and II)	Review is evaluating changes in statute, regulations, and management practices.	Under review by Presidential Task Force on Regulatory Relief
FWS: Fish and Wildlife Coordination Act (50 CFR Part 410)	Review is evaluating changes in statute, as well as regulatory and management practices.	Under review by Presidential Task Force on Regulatory Relief
Land Access Regulations: Advisory Council on Historic Preservation		
Protection of Historic and Cultural Properties (30 CFR Parts 800)	Existing rules could be unnecessarily extensive and inflexible.	Revised rules under development by Advisory Council on Historic Preservation

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Environmental Regulations
Environmental Protection Agency

Regulations	Need for Reform	Status*
RCRA	Overly burdensome RCRA regulations could impose major costs on mining industry.	Congress ordered exemption of mining industry pending completion of three-year study. Study is now under review
Clean Water Act	Review will focus upon costs and water quality benefits of best available technology standard.	Act to be reauthorized in 1982. Standards presently under review
The following regulatory programs may be affected by the pending reauthorization of the Clean Air Act.		
PSD--Fugitive Dust	Almost all western surface mines are constrained.	Appeal pending in U.S. Court of Appeals for District of Columbia
Class I Visibility Protection/Integral Vistas	Regulations could block surface mining within view of national parks or wilderness areas.	Under review
CAA Exemption for Nonferrous Smelters (Section 119)	Exemption expires 1/1/88. Could substantially increase control costs in 1988 and shut down some smelters.	Additional nonferrous smelter orders to carry beyond the two five year postponements allowed by the present statute have been proposed.
National Ambient Air Quality Standards (particulates, SO_2)	Existing standards may be based on inadequate scientific data.	Under review

Environmental Regulations
Corps of Engineers

Clean Water Act: Section 404 Dredge and Fill Permit	Review focusses on changes in statute, regulations, and practices necessary for more cost/effective attainment of environment goals.	Under review by Presidential Task Force on Regulatory Relief

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APPENDIX B

NATIONAL DEFENSE STOCKPILE POLICY DIVISION
FEDERAL EMERGENCY MANAGEMENT AGENCY

COMPARISON OF INVENTORY TO FEMA GOALS

	INVENTORY : MARCH 81 : (UNITS)	FEMA : GOALS : (UNITS)	EXCESS OR : DEFICIT : (UNITS)	EXCESS OR : DEFICIT : ($1000)	VALUE OF : DEFICIT : ($1000)	VALUE OF : EXCESS : ($1000)
ALUMINA-ST	0.	0.	0.	0.	0.	0.
ALUMINUM-ST	1733.	700000.	-698267.	-1061301.	-1061301.	0.
BAUXITE,METAL GRADE,JAMAICA -LDT	8858881.	21000000.	-12141119.	-457841.	-457841.	0.
BAUXITE,METAL GRADE, SURINAM -LDT	5299596.	6100000.	-800404.	-32408.	-32408.	0.
ALUMINUM OXIDE, ABRASIVE GRAIN-ST	50786.	0.	50786.	58912.	0.	58912
ALUMINUM OXIDE,FUSED CRUDE-ST	249867.	0.	249867.	64965.	0.	64965
BAUXITE, ABRASIVE, GRADE -LCT	0.	750000.	-750000.	-95250.	-95250.	0
ANTIMONY -ST	40729.	36000.	4729.	18916.	0.	18916
ASBESTOS, AMOSITE -ST	42533.	17000.	25533.	13175.	0.	13175
ASBESTOS, CHRYSOTILE-ST	8793.	3000.	5793.	8689.	0.	8689
BAUXITE, REFRACTORY -LCT	174599.	1400000.	-1225401.	-306350.	-306350.	0
BERYL ORE (11% BEO) -ST	17987.	18000.	-13.	-16.	-16.	0
BERYLLIUM COPPER MASTER ALLOY -ST	7387.	7900.	-513.	-5181.	-5181.	0
BERYLLIUM METAL -ST	229.	400.	-171.	-59166.	-59166.	0
BISMUTH-LBS	2081298.	2200000.	-118702.	-297.	-297.	0
CADMIUM-LB	6328809.	11700000.	-5371191.	-10743.	-10743.	0
CASTOR OIL,SEBACIC ACID-LB	5009697.	22000000.	-16990303.	-7985.	-7985.	0
CHROMITE, CHEMICAL , SDT	242414.	675000.	-432586.	-25509.	-25509.	0
CHROMITE METALLURGICAL , SDT	1956824.	3200000.	-1243176.	-159126.	-159126.	0
CHROMIUM, FERRO, HIGH CARBON-ST	402003.	185000.	217003.	150481.	0.	150481
CHROMIUM, FERRO, LOW CARBON-ST	300192.	75000.	225192.	295227.	0.	295227
CHROMIUM, FERRO, SILICON-ST	56986.	90000.	-33014.	-24695.	-24695.	0
CHROMIUM, METAL-ST	3763.	20000.	-16237.	-138012.	-138012.	0
CHROMITE, REFRACTORY GRADE ORE-SDT	391414.	850000.	-458586.	-43268.	-43268.	0
COBALT-LB CO	40802393.	85400000.	-44597607.	-1114940.	-1114940.	0
COLUMBIUM CARBIDE POWDER-LB CB	21372.	100000.	-78628.	-2218.	-2218.	0
COLUMBIUM CONCENTRATES-LB CB	911239.	5600000.	-4688761.	-67097.	-67097.	0
COLUMBIUM, FERRO-LB CB	598410.	0.	598410.	3764.	0.	3764
COLUMBIUM, METAL-LB CB	44851.	0.	44851.	1776.	0.	1776
COPPER-ST	28444.	1000000.	-971556.	-1915923.	-1915923.	0
CORDAGE FIBERS, ABACA-LB	0.	155000000.	-155000000.	-80600.	-80600.	0
CORDAGE FIBERS, SISAL-LB	0.	60000000.	-60000000.	-24000.	-24000.	0
DIAMOND DIES, SMALL-PC	25473.	60000.	-34527.	-1553.	-1553.	0
DIAMOND, INDUSTRIAL, CR. BRT.-KT	23692782.	22000000.	1692782.	4317.	0.	4317
DIAMOND, IND STONES-KT	18723796.	7700000.	11023796.	245550.	0.	245550
FEATHERS AND DOWN-LBS	0.	1500000.	-1500000.	-21825.	-21825.	0
FLUORSPAR, ACID GRADE-SDT	895350.	1400000.	-504650.	-70651.	-70651.	0
FLUORSPAR,METALLURGICAL GRADE-SDT	294875.	1700000.	-1405125.	-136998.	-136998.	0
GRAPHITE, NATURAL-CEYLON,AMO LUMP-ST	5442.	6300.	-858.	-813.	-813.	0
GRAPHITE,NATURAL-MALAGASY CRYSTALLINE-ST	17906.	20000.	-2094.	-1392.	-1392.	0

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NATIONAL DEFENSE STOCKPILE POLICY DIVISION
FEDERAL EMERGENCY MANAGEMENT AGENCY

COMPARISON OF INVENTORY TO FEMA GOALS

	INVENTORY MARCH 81 (UNITS)	FEMA GOALS (UNITS)	EXCESS OR DEFICIT (UNITS)	EXCESS OR DEFICIT ($1000)	VALUE OF DEFICIT ($1000)	VALUE OF EXCESS ($1000)
GRAPHITE,NATURAL-OTHERS-ST	1933.	2800.	-867.	-158.	-158.	0.
IODINE-LB	8009811.	5800000.	2209811.	15756.	0.	15756.
JEWEL BEARINGS-PC	54133806.	120000000.	-65866194.	-63890.	-63890.	0.
LEAD-ST	601026.	1100000.	-498974.	-359262.	-359262.	0.
MANGANESE, BATTERY GRADE,NATURAL-SDT	190864.	62000.	128864.	10567.	0.	10567.
MANGANESE,BATTERY GRADE, SYN-SDT	3011.	25000.	-21989.	-21989.	-21989.	0.
MANGANESE ORE, CHEMICAL GR-SDT	220955.	170000.	50955.	4178.	0.	4178.
MANGANESE ORE, METALLURGICAL GR-SDT	2409377.	2700000.	-290623.	-21236.	-21236.	0.
MANGANESE, FERRO, HIGH CARBON-ST	599978.	439000.	160978.	73303.	0.	73303.
MANGANESE,FERRO, LOW CARBON-ST	0.	0.	0.	0.	0.	0.
MANGANESE, FERRO, MEDIUM CARBON-ST	28920.	0.	28920.	21950.	0.	21950.
MANGANESE, FERRO, SILICON-ST	23574.	0.	23574.	11551.	0.	11551.
MANGANESE METAL, ELECTROLYTIC-ST	14172.	0.	14172.	19841.	0.	19841.
MERCURY-FL	191391.	10500.	180891.	75070.	0.	75070.
MICA, MUSCOVITE BL, ST & BET-LB	5005704.	6200000.	-1194296.	-6460.	-6460.	0.
MICA, MUSCOVITE FLM, 1ST & 2ND-LB	1273855.	90000.	1183855.	13881.	0.	13881.
MICA,MUSCOVITE SPLT-LB	19035162.	12630000.	6405162.	12810.	0.	12810.
MICA, PHLOGOPITE BLK-LB	16718.	210000.	-193282.	-416.	-416.	0.
MICA, PHLOGOPITE SPLT-LB	1918265.	930000.	988265.	988.	0.	988.
MOLYBDENUM DISULPHIDE-LB MO	0.	0.	0.	0.	0.	0.
MOLYBDENUM, FERRO-LB MO	0.	0.	0.	0.	0.	0.
NICKEL-ST NI+CO	0.	200000.	-200000.	-1400000.	-1400000.	0.
OPIUM, GUM-AMA-LB	31795.	0.	31795.	6715.	0.	6715.
OPIUM, SALT-AMA LB	39508.	130000.	-90492.	-52388.	-52388.	0.
PLATINUM GROUP METALS, IRI-TR OZ	16991.	98000.	-81009.	-48607.	-48607.	0.
PLATINUM GROUP METALS, PALL-TR OZ	1252788.	3000000.	-1747212.	-244609.	-244609.	0.
PLATINUM GROUP METALS,PLAT -TR OZ	439597.	1310000.	-870403.	-413440.	-413440.	0.
PYRETHRUM-LB	0.	500000.	-500000.	-6125.	-6125.	0.
QUARTZ CRYSTALS-LB	2820838.	600000.	1820838.	10925.	0.	10925.
QUINIDINE-AV OZ	1798762.	10100000.	-8301238.	-35697.	-35697.	0.
QUININE-AV OZ	2770214.	4500000.	-1729786.	-5536.	-5536.	0.
RUBBER-LT	119208.	850000.	-730792.	-1055850.	-1055850.	0.
RUTILE-SDT	39130.	106000.	-66870.	-21732.	-21732.	0.
SAPPHIRE AND RUBY-KT	16305502.	0.	16305502.	179.	0.	179.
SILICON CARBIDE, CRUDE-ST	80548.	29000.	51548.	23197.	0.	23197.
SILVER (FINE)-TR OZ	139500000.	0.	139500000.	1848375.	0.	1848375.
TALC, STEATITE BLK & LMP-ST	1092.	28.	1064.	394.	0.	394.
TANTALUM, CARBIDE POWDER-LB TA	28688.	0.	28688.	4970.	0.	4970.
TANTALUM METAL-LB TA	201033.	0.	201033.	28145.	0.	28145.
TANTALUM MINERALS-LB TA	1399143.	8400000.	-7000857.	-812101.	-812101.	0.

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COMPARISON OF INVENTORY TO FEMA GOALS

	INVENTORY MARCH 81 (UNITS)	FEMA GOALS (UNITS)	EXCESS OR DEFICIT (UNITS)	EXCESS OR DEFICIT ($1000)	VALUE OF DEFICIT ($1000)	VALUE OF EXCESS ($1000)
THORIUM NITRATE-LB	7141812.	600000.	6541812.	17990.	0.	17990
TIN-LT	200112.	42000.	158112.	2291839.	0.	2291839
TITANIUM SPONGE -ST	21465.	195000.	-173535.	-2505849.	-2505849.	0
TUNGSTEN CARBIDE POWDER-LB W	1921167.	2000000.	-78833.	-1171.	-1171.	0
TUNGSTEN, FERRO-LB W	840752.	0.	840752.	10005.	0.	10005
TUNGSTEN, METAL POWDER-LB W	1566964.	1600000.	-33036.	-459.	-459.	0
TUNGSTEN ORES & CONCENTRATES-LB W	57113166.	55450000.	1663166.	14769.	0.	14769
VANADIUM, FERRO-ST V	0.	1000.	-1000.	-14100.	-14100.	0
VANADIUM PENTOXIDE-ST V	541.	7700.	-7159.	-77955.	-77955.	0
VEGETABLE TANNIN , CHES -LT	16717.	5000.	11717.	6326.	0.	6326
VEGETABLE TANNIN , QUEB-LT	142691.	28000.	114691.	67644.	0.	67644
VEGETABLE TANNIN, WATTLE-LT	16397.	15000.	1397.	782.	0.	782
ZINC-ST	375970.	1425000.	-1049030.	-894297.	-894297.	0
TOTAL				-8470568.	-13928488.	5457921

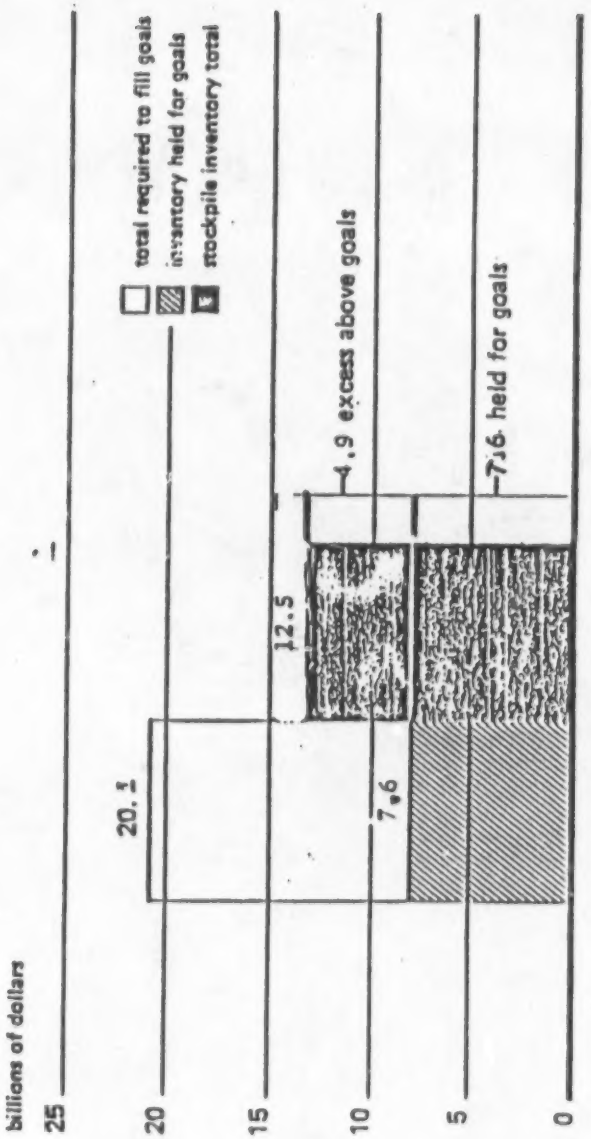

Figure 1
Restructuring of stockpile to meet 1980 goals.

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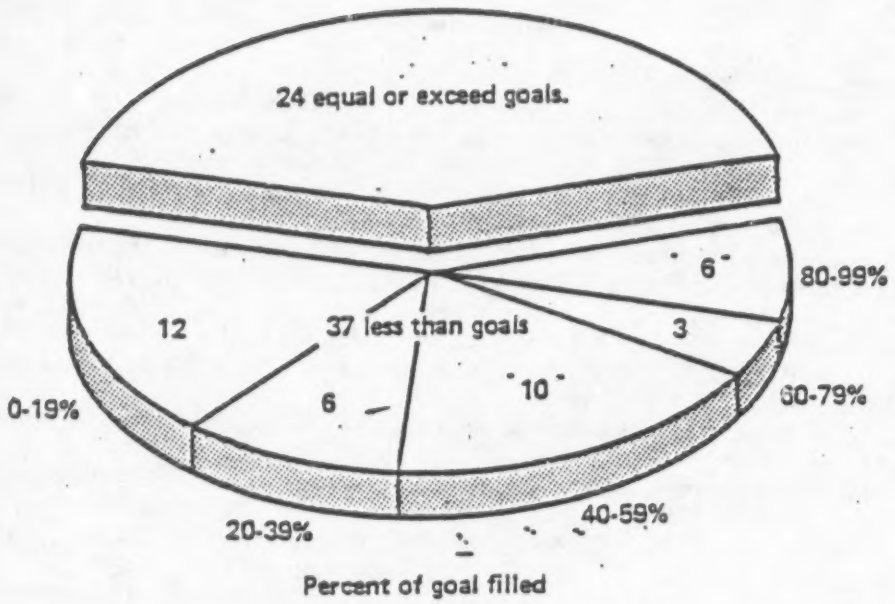

Figure 2

Status of the 61 family groups and individual materials in the stockpile inventory toward meeting the 1980 goals.

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